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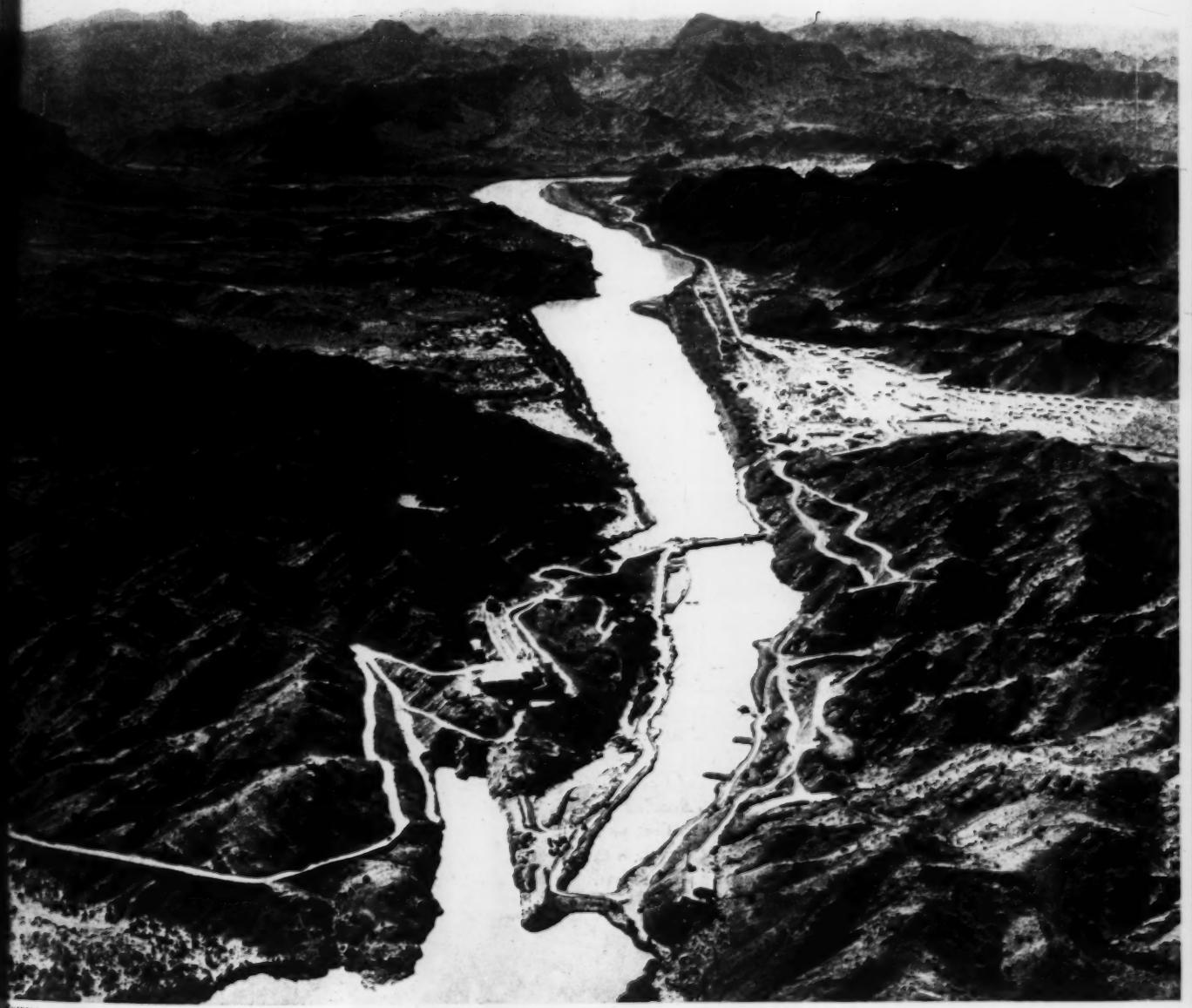

Site of Parker Dam on the Colorado River. The river is diverted through the left-bank tunnels

AQUEDUCT SIZE AND SLOPE

First of two articles by Julian Hinds on the fundam

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"Oil For the Minds"

A FEW weeks ago a manufacturer of lubricants ran in this journal an advertisement that bore the head, "oil for the *minds* in your plant." Its purpose was to feature the advisory service offered by the manufacturer to his customers. But in the phrasing of that head is expressed an idea of far wider significance.

Oil for the *minds* of all industry is a primary essential of industrial progress, and that means of social progress. For we are living in a society that has become largely industrial; its general progress depends chiefly on that of its industry. The production of more and more things that men need and their more widespread distribution per unit of human effort are the only tests by which we are able to measure our climb to higher social standards.

Obviously two men may apply the same amount of power to the same raw materials with strikingly different results. The one may waste both materials and power and have less to show for them when he is finished than he had when he started. The other may produce from the combination a more useful material or a more helpful service that may contribute mightily to the general good.

The difference is due to the third element of industrial production; the "know-how", the intangible factor that constitutes the difference between mere labor and productive effort. Its ingredients are knowledge and experience, skill and judgment. They are the fruits of research and observation, of vision and enterprise, of inspiration and perspiration. These, indeed, are the lubricants by which men's minds are enabled to work more smoothly and productively with less waste of energy through friction and futile effort.

THE purpose of journals such as this is to help perform this service to those engaged in the industries they serve. To observe, assemble and report the findings and experience of both research and practice; to review and interpret the significance of current developments; to stimulate by critical appraisal the exchange of views that helps to clarify conflicting opinion: these are their more specific functions.

Then, too, they must offer an opportunity for the producer of materials and machines to perform his part of the same task. For he, too, is prosecuting research, observing practice and building the ideas of his staff into his product, to the end that it may serve more effectively the needs of its users.

Thus both the editorial and advertising pages of a well-edited industrial journal are "oiling the minds" of those who are responsible for the march of the industry. And the more rapid the tempo of an industry or the greater the resistance it must overcome, the more vital becomes this function.

MUCH is written in these days concerning obsolescence, and very properly written. Most of it concerns the obsolescence of material things, of plant and equipment. But there is another obsolescence that fosters material obsolescence and that takes even heavier toll of industrial progress. It is the obsolescence of methods and management. It is measured by the lag of the average efficiency behind the highest attainable efficiency. It can be reduced only by speeding up the exchange and application of the information and experience that make for the most advanced practice.

Only as we do this can we make effective use of what science teaches us and increase the general capacity to produce more of what we need per unit of our effort. And as that is the ultimate social objective of all economic activity, it will be evident that the "oiling of minds" is indeed a vital function in the modern social scheme.

Willard Chevalier

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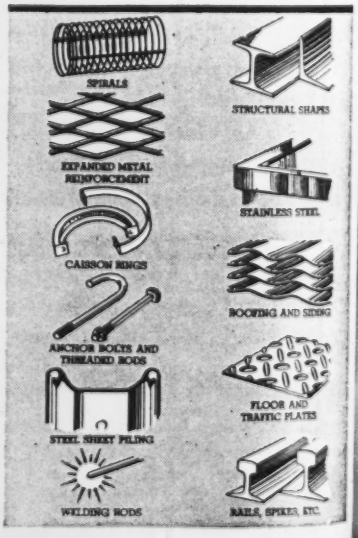

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JANUARY 28, 1937

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■

In The Flood Zone—Two Editors of Engineering News-Record left for the flood zone on January 22 to give this journal's readers first-hand news of the events of engineering interest.

- **Next Week**—The Annual Review Number containing the significant statistics of the construction industry and a group of authoritative articles on major civil engineering developments.

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ENGINEERING NEWS-RECORD
January 28, 1937

West portal of San Jacinto tunnel, major elevation control point of Colorado River Aqueduct

Economic Water Conduit Size

By Julian Hinds

Assistant Chief Engineer, Metropolitan Water District of Southern California, Los Angeles

Methods for determining the most favorable adjustment of size and slope of multi-part water conduit lines to elevation controls as used on the Colorado River Aqueduct

IN ANY CANAL or conduit system, hydraulic head has value because of the cost of producing it as the upstream end of the system, its usefulness at the outfall end, its usefulness for the production of flow in the conduit system, or a combination of these factors. There is always a definite relation between size of conduit, hydraulic slope, and value of head. Where tunneling is involved, and sometimes in other cases, the cost of construction varies with the general elevation of the line. The head which must be produced, or that remaining for use at the end of the conduit, varies with elevation of the line, as well as with the hydraulic slope. The economic relationships between the various factors involved are fundamentally simple, but may become complex in long lines composed of many kinds of conduit and traversing varied terrain.

Means for coordinating the component parts of such a line, and for choosing a proper height of diversion dam, pump lift, or power drop, are developed in the present article. It deals with hydraulic-grade lines, i.e. lines not under pressure. Pressure pipe line design economics will be considered in a later article.

The graphical methods of treatment used are not original but are believed to be presented more fully and logically than heretofore.

The paper, although general in nature, is based upon economic studies made in connection with the design of the Colorado River Aqueduct being constructed by the Metropolitan Water District of Southern California.

The Colorado River Aqueduct

Taking water from the Colorado River just above Parker Dam (which is now being built) the aqueduct extends westward to the Los Angeles region. It is designed to convey a peak flow of 1,605 sec.-ft. to the coastal area of southern California. As shown in Fig. 2, it traverses several hundred miles of mountainous desert terrain and is composed of open canals, cut-and-cover conduits, tunnels, and pressure pipes. The water level at the point of diversion is 450 ft. above sea level. The areas to be served range up to 1,000 ft. and more above sea level, and are separated from the river by a divide with lowest point at San Gorgonio Pass, El. 2,600 ft. The project necessarily involves pumping, and the proper balancing of construction and operating costs is of first importance.

From diversion to its discharge into Cajalco Reservoir, 242 mi., the main aqueduct is concrete-lined throughout. It is composed of various lengths and types of conduit. Several hundred miles of distributing lines will be required west of Cajalco Reservoir.

To fit such a long and varied conduit to the terrain with maximum overall economy is a problem that involves geological and topographical factors not susceptible to mathematical treatment. However, when these factors are dealt with by judgment or by trial

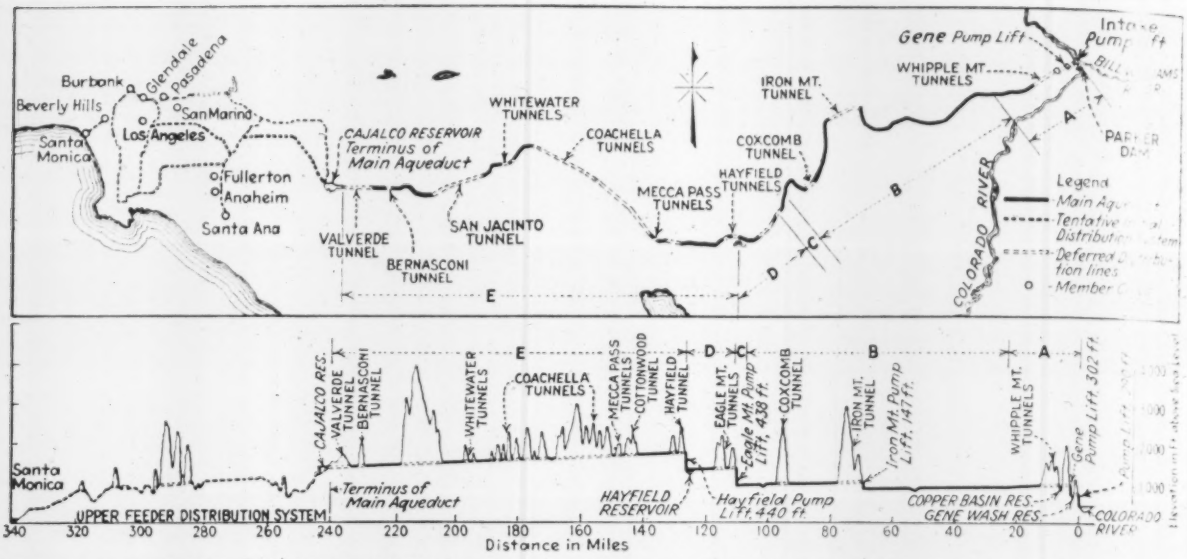


FIG. 2—THE COLORADO RIVER AQUEDUCT spans 242 miles of desert and mountain from the Colorado River to the coast cities and rises to 2,600 feet above sea level.

solution, the slope and size relations may be determined by analytical procedure.

Any conduit carrying water must have a slope sufficient to cause the desired discharge to flow through it. If the slope is very steep, the water will flow at high velocity and a small conduit will suffice. Consequently, if sufficient fall is available and the channel walls are of concrete or other erosion-resisting material, steep slopes are economical. When elevation can be obtained only through an expensive dam or pumping plant, however, a flatter and larger conduit must be adopted to hold down the cost of the lift. Some combination of lift and slope will therefore give the greatest over-all economy, operating cost included.

I—The Economic Theory

Every water line has some controlling feature that determines its general elevation. This control may be the terminal reservoir or delivery system into which the line discharges, the source of supply, or some intermediate feature. In the case of the Colorado River Aqueduct, the general elevation of the line is determined by the requirement for minimum lengths of tunnels. Tunnels cost more per lineal foot than surface conduits. To bore straight through a mountain range at its base may be very expensive, and to pump entirely over it is likewise costly. Consequently, it was found necessary to lift the water to a somewhat greater height than otherwise required, to avoid excessive tunneling costs.

Simple slope determination

The fundamentals of economic location are illustrated in Fig. 3, where a given flow of water must be transported from the supply at *A*, through the pump line *AC* and the grade tunnel *CB*, to the reservoir at *B*. Evidently the water must be lifted to a sufficient height above *B* to permit of a friction gradient steep enough to keep the cost of the tunnel within reasonable limits. The best diameter of the tunnel may be found as illustrated in Fig. 4, where the curve *AB* represents the total construction cost of the tunnel for varying slope, *CD* represents the capitalized cost of elevating the water through the heights corresponding to the various tunnel slopes, perpetually or for such period of time as the system is to be operated, and curve *EFG* represents the combined cost, which is the sum of the first two curves. The lowest point on this curve, at *F*, marks the most economic slope for the tunnel.

Curve *EFG* may be omitted and the economic slope determined by finding on curve *AB* the point *L* where the slope is numerically equal to the slope of the curve *CD* on the same vertical. To do this, plot a tangent *QR* to the curve *CD* at some estimated point *P*, and draw some line *CK* with the same in-

FIG. 3

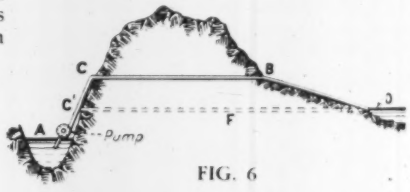


FIG. 6

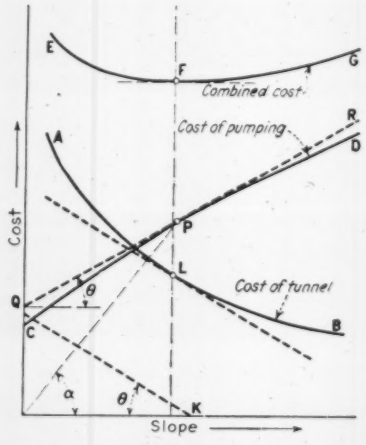


FIG. 4

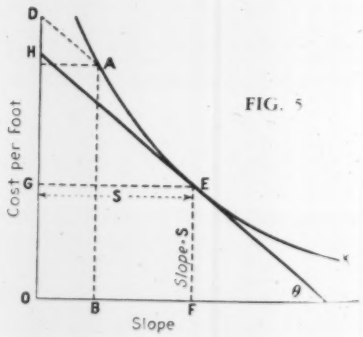


FIG. 5

FIGS. 3-6—THE COST OF PUMPING and the cost of tunnel construction for different conditions can be balanced by graphical process to determine the most economical manner of getting through a mountain range.

elimination, but reversed. Then move upward parallel to CK to determine a tangent to AB at L (if L and P do not lie approximately on the same vertical, assume a new position for P and repeat). The slope of the line QR in terms of the co-ordinates of the diagram is equal to the cost of an *additional* foot of head at the point P; if this cost can be determined directly, curve CD need not be drawn to draw CK. Obviously, too, the curve AB may represent the cost of only one foot of the tunnel, rather than its whole length, since its variation with tunnel slope is the only factor at issue.

This method of locating the economic slope, which will be referred to as the "slope tangent method," appears cumbersome for the simple conditions of Fig. 3, but it has many advantages in more complicated cases, as will appear. Its correctness is apparent from the previous discussion, but a further demonstration by use of Fig. 5 brings out a property which assists in understanding the application of the method.

Slope-tangent method

Let curve AEK of Fig. 5 represent the cost-slope relation for a given type of conduit of given capacity in a particular location. Draw the tangent HE so that tan θ is equal to the cost of an additional foot of head, that is, parallel to a line similar to CK in Fig. 4. From the point of tangency E draw the vertical EF and the horizontal EG; then, let the slope at F be designated by $S = OF = GE$. Then,

$$\frac{GH}{GE} = \tan\theta = \text{cost of one foot additional head}$$

$GH = GE$ times cost of one foot additional head

$= S$ times cost of one foot additional head

= Cost of head consumed per horizontal foot of conduit.

The cost of the conduit itself, per linear foot, is represented by the ordinate FE, or its equal OG; hence, the combined cost of a foot of conduit and the head required to overcome the friction in it at the established rate per additional foot of head is OH. Note here that the ordinate OH makes no allowance for the portion OQ of cost of pumping in Fig. 4, but as this same addition must be made to both OH and OD, or any similar ordinate, OH is an accurate index of the smallest cost, but does not ordinarily represent the *complete* combined costs and cannot be used for estimating purposes.

Evidently the combined cost OD, derived in the same way for point A on the curve, will be greater than OH; hence the point of tangency E marks the "best slope" for the conduit represented by the curve AEK. If the curve AEK is in any way irregular, the point E should be chosen so that the line HE will be in the lowest position possible for any tangent.

This method of finding economic slopes was used by Thomas Wiggin in the design of the Catskill Aqueduct (see Lazarus White, "Catskill Water Supply of New York City," John Wiley & Sons, 1915); see also Babbitt & Doland, "Water Supply Engineering" McGraw-Hill Book Co., 1929, p. 236), and was used in the design of the Owens River Aqueduct of the City of Los Angeles.

The example of Fig. 6 differs from that of Fig. 3 by the addition of the extension BD, which, although relatively flat, provides more slope than would normally be required for the surface line BD. Whether the water should be lifted to C, run through the tunnel CB and the inexpensive surface line BD, or lifted to C' and delivered through the longer tunnel $C'D$, may not be apparent, but may be determined by trial estimates.

The control point of elevation is first assumed at B and an estimate prepared for the line $ACBD$, determining the lift as in the example of Fig. 3. Then the control is assumed to be at D, and a similar estimate prepared for the line $AC'FD$. If the total cost of pumping plus the capitalized cost of pumping is less for $ACBD$ than for $AC'FD$, then the control is at B, otherwise it is at D. If the slope BD is irregular, it may be necessary to try out several possible control points.

If fall at D has any value for the production of power, or for other purposes, such value must be taken into account in determining the economic slope of the line BD and in comparing the estimate for the two alternative plans. If the construction costs of the portions $C'F$ and FD of the longer tunnel are expected to differ, then the economic slope of each portion must be determined separately, with due consideration to the cost of forms and similar items if two different tunnel sizes are used.

If the control is at B, then the slope of any conduits to the right of B will depend on the value of fall for the production of power at D, or on some other factor independent of the cost of pumping at A. If the value of head at D exceeds that at A, then the control will be at D, perhaps at a higher elevation. Comparison of cost factors and physical conditions will indicate in what region the control should be sought.

FIG. 7—**LONG AQUEDUCTS** generally combine several types of conduit, for each of which a particular slope gives lowest annual cost.

FIG. 8—**THE ECONOMIC SLOPES** for the several types of conduits is determined by the points at which lines parallel to the line AB (obtained from the cost-of-dam curve Fig. (9) are tangent to the conduit cost curves.

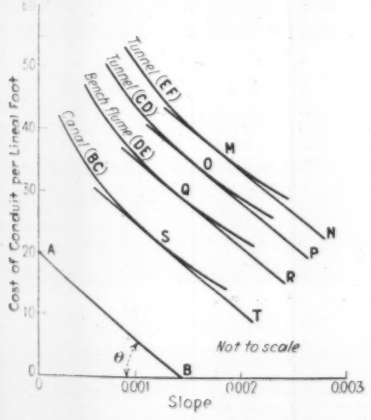


FIG. 9—**THE BEST HEIGHT** of dam for diversion into a conduit is determined from the economic conduit slopes, after these are found by the method of Fig. 9.

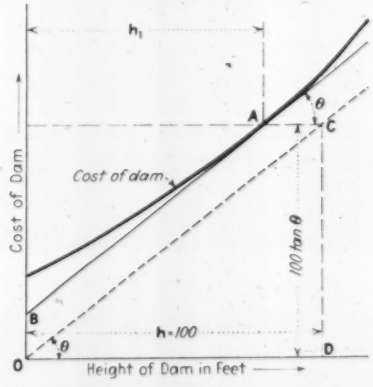
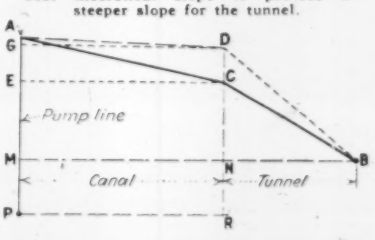


FIG. 10—**OVERALL ECONOMY** cannot be improved by a combination in which the canal slope is made flatter than the best theoretical slope to provide a steeper slope for the tunnel.



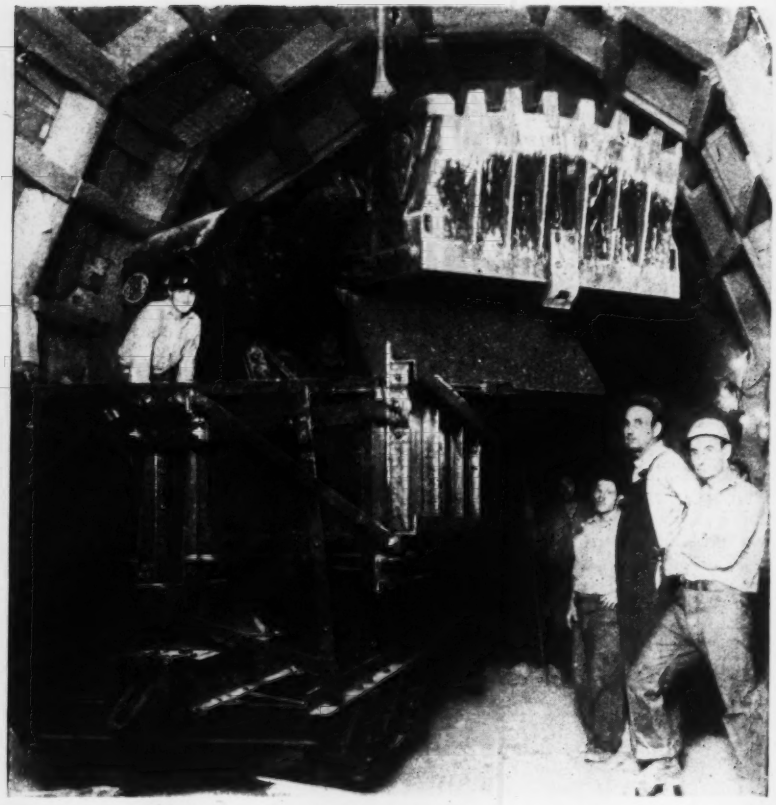


FIG. 11—WHERE A SHOVEL IS AVAILABLE the cost of tunneling may change sharply somewhere between the 20-ft. and the 15-ft. size.

II—General Rules of Procedure

In the example of Fig. 7, it is required to divert a given flow from the river G by a dam AB, convey it along the line $BCDE$, and deliver it through the divide H to the point F and from there onward to the lake at K.

It will be assumed that the reach BC is on smooth hillside where an open canal is possible, that CD is very rough and will require tunneling, that DE is moderately smooth and is suitable for a bench flume. The summit reach EF will need to be tunnel unless the summit H is surmounted. A power drop is located at J. The problem is to find the conduit slopes and locations that will give the most advantageous complete installation.

Subject to subsequent checking, the point F is taken to control the general elevation of the line. Determination of the economic slopes may proceed as follows:

1. Plot at set of curves showing the relation of the cost per linear foot of the various types of conduit to their hydraulic slopes, as in Fig. 8. These curves may be approximate in preliminary work, or may take into account all physical detail where greater exactness is required. They must correspond to the fixed discharge that is to be carried.

2. Plot a cost curve for the dam as in Fig. 9. Take a trial height for the dam, as h_1, and draw a corresponding tangent to the cost curve, as AB. The slope of this line, in terms of the coordinates of the diagram, is the cost of an additional foot of dam at the height h_1. This slope may be conveniently determined by transferring the tangent to the origin and taking 0.01 of the intercept on the $h = 100$ line, as at C.

3. On Fig. 8, draw any line AB, making an angle θ with the horizontal such that tan θ equals the cost of an additional foot or dam in the vicinity of the assumed trial height. That is, the tan θ in Fig. 8 is made numerically equal to tan θ of Fig. 9 (the two angles will not generally appear equal because of the different scales of the two diagrams).

4. Draw tangents MN, OP, QR, and ST, to the cost curves on Fig. 8, all parallel to AB. The points of tangency S, Q, O, and M mark the economic slopes for the curves upon which they fall.

5. With these slopes, the known or assumed elevation of F, Fig. 7, and other available data, compute the required elevation of the top of the dam B.

6. If the elevation thus obtained gives a height of dam sufficiently different from the trial height to cause a material change in the slope of the line AB, Fig. 9, make a new trial until a satisfactory agreement is secured.

The above procedure establishes the most economical relationship between the height of the dam and sizes and slopes of the various types of aqueduct between points G and F. From point F to K, the economy of location depends on the value of the power developed in the drop JK. The procedure of analysis is similar to that outlined in steps 1 to 6.

7. Assume a trial height of power drop at J and estimate the value of a foot of head there, either analytically or by plotting a curve, similar to the cost-of-dam curve in Fig. 9.

8. On Fig. 8, or a similar diagram, plot cost curves for the various types of conduit between F and J.

9. Draw on Fig. 8 a new line similar to AB but having tan θ equal to the value of a foot of head at J.

10. Draw tangents to the cost curves for the conduit sections between F and J parallel to the new slope line. The points of tangency mark the economic slopes.

11. Using the slopes thus found and the known lengths of line, compute the outfall elevation.

12. If the elevation thus secured gives a height of power drop sufficiently different from that assumed to materially affect the value of a foot of fall at J, make a new trial assumption and repeat the solution.

13. If the drop at J has little or no value for the production of power or for other purposes, the drop, determined as outlined, will be *negative;* a foot of head having more value for overcoming friction than for the production of power. The drop should be made zero, and the economic slopes determined as will be later described.

14. If the value of a foot of head is greater to the right of F than to the left, the control will then be to the right. For example, if the water had to re-pumped at F, Fig. 7, and if the cost of pumping there exceeded the cost of making the additional lift at B, then the line would be lifted until that ceased to be true. Point F would thus become the control.

15. If at this point there is any question as to the correctness of the chosen point of control, or of the elevation at the control, make a new assumption, repeat the analysis, and compare estimates, continuing until all doubt is removed.

This procedure has the advantage of immediately establishing, for each trial, the proper relation between the slopes and sizes of the various types of conduits. This fact is somewhat difficult

to visualize. A typical and persistent question is:

After the economic slopes for the individual conduits have been determined, is it possible to improve the over-all economy by using less than the theoretical slope for inexpensive portions of the line, such as open canals, thus conserving head which may be used to steepen the more expensive parts, such as tunnels?

The answer is evident from an analysis of Fig. 10, where it is required to transmit a specified flow from point *P* to point *B* through pump line, canal, and tunnel, as indicated. Points *P* and *B* are assumed fixed in elevation. Taking the point *B* as a control and using cost-slope curves for tunnel and canal similar to those shown in Fig. 8, the economic slope for the tunnel is found to be *BC* and that for the canal *CA*. Consider, then, whether the overall economy might be increased by flattening the canal to some slope *AD* and steepening the tunnel to slope *DB*. Because *CB* is the economic slope for the tunnel, the combination of operating and construction costs for lifting the water from *R* to *C* (or through the equal height *PE*) and constructing the tunnel *CB* will be less than for any other combination such as *RD* and *DB*. Also, *AD* being not the economic slope of the canal, the cost of elevating water from *G* to *A* and constructing the canal *AD* will be greater than for the combination *EA* and *AC*. Therefore, since the combination of operation and construction cost is increased for both the canal and the tunnel by changing from *C* to any point *D*, it follows that the cost of both together will be likewise increased. The total lift, from *P* to *A*, being constant, it follows that the cost of construction on the slopes *AC* and *CB* is a minimum. Hence, the economic slope principle is applicable, whether pumping is involved or not, as will be brought out subsequently. This line of argument can be extended to any number of conduit types used in combination.

It should be noted that the location of the point of tangency as *E*, Fig. 5, is somewhat indefinite, and that a considerable variation in the selection of the economic slope may affect the combined cost but little, so that slight departures from the theoretical may be made to secure practical advantages.

Locating the point of control

The point of control exerts a profound influence on the cost of the entire line and should be selected with care. In simple cases it may be found mathematically, but generally comparative estimates are safer. Even in the simplest cases the selecting of control should not be passed over too lightly. For example, if the reservoir level at *B*, Fig. 3, is definitely fixed, there is no doubt where the tunnel should end; but if the level is capable of being varied, the tunnel may be raised or lowered until the value of an additional foot of reservoir depth just balances the cost of an additional foot of lift at *C*, due allowance being made for any variation in the length of tunnel. Practical cases are seldom so simple. A change of elevation at *F*, Fig. 7, may affect the cost of many features besides the tunnel, *EF*. These changes can best be accounted for by complete comparative estimates. If the trial controls are carefully chosen, the number of comparative estimates required will not be large.

The control on a surface line may be the saddle of some pass that must be attained, a depression that must be crossed, or any other feature that requires a definite elevation and location at a given point. A control at the end of a tunnel usually comes at an abrupt change in slope, where the mountain meets the plain, and may be at either end. If a tunnel is projected through a low plateau, with steep margins, the possibility of pumping over the top of it should always be investigated, as study of the side slopes might lead to the selection of an incorrect control. Other possibilities of false control should be carefully checked.

The control point on the Colorado River Aqueduct is at the outlet of the San Jacinto Tunnel, which pierces the divide between the Colorado River watershed and the Pacific slope. The mountain slope at this point is steep. The flanking plain is quite flat and is of such a nature that it cannot be readily tunneled; hence, the actual outlet end of the tunnel was predetermined. The variable items were the cost of the approach cuts at the two ends and a slight variation in tunnel length at the inlet. As the tunnel grade was lowered, the approach cuts increased in length and depth, until a point was reached at which the cost of another foot of digging added more than the capitalized value of one foot of head.

The cost of the aqueduct upstream from San Jacinto was more or less independent of the tunnel elevation, but the cost of the line downstream increased slightly as the tunnel outlet was lowered. The problem was further complicated by the presence of groundwater comparatively close to the

FIG. 12—PARKER DAM on the Colorado will form the pool from which the aqueduct water is pumped. This view, looking downstream, shows the river diverted through tunnels in the left bank and the cofferdams under construction.

surface of the plain at the outlet. All of these factors were fully considered in trial estimates. The theoretical depth of cut took the tunnel down deeper into the groundwater than was considered practicable or advisable, and thus the intersection of the groundwater level with the mountain slope was the final point of control.

The head available between this point and the terminal reservoir was greater than required for economic slopes corresponding to the cost of pumping, and as conditions did not favor a return power plant the slopes were adjusted as described under the subsequent heading of "Unknown or indefinite value of head." Tunnel and conduit sizes were smaller in this reach than on the eastern part of the line, although the discharge is the same throughout.

In preparing the estimates for the cost-slope curves, particular attention must be given to consistency between estimates for conduits of various sizes. Cost usually does not vary directly as the units of work involved. Doubling the construction quantities for a channel of ordinary dimensions is not likely to double its cost. The cost of roads, camps, water supply, power, telephones, bringing in equipment, and moving it along the line; overhead, and some plant items, are partially independent of the volume of work. Unit costs usually decrease with an increase in size, until the structure begins to exceed the capacity of standard equipment. These variations are of great importance and require that the estimates be carefully broken down into elements, the variations of which can be determined.

The construction of surface channels is more or less standardized, and cost analyses upon which to base detailed estimates are usually available. Satisfactory estimates for tunnels are much more difficult to make. Tunnels are more individual than other structures and tunnel construction procedures have not been fully standardized. It is difficult to get any two estimators to agree on the relation of tunnel cost to size. It will perhaps always remain difficult to determine the cost-slope relation for a tunnel with precision, but curves of practical accuracy can be constructed.

Computing tunnel costs

On the Colorado River Aqueduct, tunnel estimates were broken down into constant and variable portions. The excavation plant charge was divided into two equal parts and the assumption made that one-half of the charge will remain constant for any particular tunnel, regardless of its diameter, while the other half will vary with the size, remaining uniform per cubic yard of material excavated. A small separate item for repairs to equipment was assumed to vary so that per cubic yard it increased as the yardage.

The costs for explosives, labor, and power, were divided, and that part of these items used in driving shafts and adits was considered as constant per linear foot of tunnel on the assumption that these items cost the same regardless of tunnel size. All the preliminary estimates were based on the use of a top or center heading, with a ring or a bench removed as a separate operation. Power, labor, and powder costs for the heading were assumed constant, as the heading size was independent of tunnel size. Items for the enlargement were assumed to vary with the yardage.

The power for transporting and hoisting materials out of the tunnel was applied uniformly over the entire excavation yardage. The concrete plant was considered constant per linear foot of tunnel, and repairs to concrete plant were treated in a way similar to repairs for excavation plant. Special assumptions were required at times to suit local conditions. The assumptions made seem to have worked [illegible] satisfactorily.

The availability of suitable [illegible]nstruction equipment may materia[illegible] affect the cost-slope curve. A tunne[illegible] of 20-ft. clear diameter can readily be [illegible]xcavated with a small shovel, while a 1[illegible] ft. tunnel cannot. Assuming that [illegible] shovel is available, but that smaller [illegible]ucking equipment, if required, must be purchased new, there will be a [illegible]reak in the cost-curve somewhere between the 20-ft. and the 15-ft. sizes. Similar conditions occur in other work and must be taken into account in preparing cost curves. These factors are most important on relatively short jobs, which can be completed with used equipment.

Where the cost curve represents a single foot of conduit, rather than the full length, an average cost must of course be used. The cost of a tunnel, canal, or other channel, may vary from station to station, due to changing physical conditions. Theoretically a new curve should be platted for each change in cost and a separate economic

FIG. 13—COSTLY CONDUIT CONSTRUCTION justifies care in selecting the slope and cross-section that will give greatest over-all economy.

FIG. 14—**FORMS ARE AN IMPORTANT FACTOR** in conduit size. Frequent changes are undesirable because they call for costly changes in forms.

size determined. However, frequent changes in size are objectionable, and usually are expensive. A short length of a special size of conduit may cost more than an equal length of a larger standard size, because of the necessity of providing a separate set of forms, or for some other reason. As a rule, standard sizes and slopes should be adhered to. But there are exceptions to this rule; examples are short lengths of deep cutting in canal construction, and variable diametered steel pipes.

Cost or value of head

The value of tan θ may depend on the cost of a dam to give the water its required elevation, the capitalized cost of pumping, or whatever other item may determine the cost or value of elevation.

In the case of pumping, the capitalized cost per foot may be taken from a curve, in the same way as for the dam previously described, and must include the cost of the pumping plant, the delivery pipes, and other appurtenances, plus the investment required to capitalize or endow its perpetual operation for the contemplated carrying capacity of the aqueduct. If the amount of water contemplated to be delivered is variable, this fact should be considered in figuring the capitalized operating charge.

Generally the cost-of-pumping curve, and even the cost-of-dam curve, is so nearly a straight line in the limited region of investigation that the construction of a curve is unnecessary—the cost of an additional foot is found with sufficient accuracy by dividing the cost difference for two adjacent estimates, at approximately the correct elevation, by the corresponding difference in height. It is *not* permissible, however, to use the average cost, obtained by dividing a single estimated value by its corresponding total lift; the angle α cannot be substituted for θ in Fig. 4.

The value of a foot of head for the production of power, as at *J*, Fig. 7, is determined by subtracting the estimated cost of plant, transmission lines, etc., from the capitalized value of the estimated net power revenue. If this value is not approximately a straight-line function of the height in the region of investigation, it may be plotted on a height-value curve and the proper value for the angle θ determined in the same manner as for the cost of dam, Fig. 9.

On the Colorado River Aqueduct, increasing the lift involves an increase in the first cost of pumping equipment, the cost of power consumed annually, the cost of operation, and the cost of maintenance and repairs. Annual expenditures will be variable, increasing as the demand for water grows; and the capitalized value of these variable expenditures depends on the prevailing interest rate, which may also vary. The procedure followed in computing the cost of pumping a total height of 1,600 ft. in the five aqueduct pumping plants is shown in the table on page 120. A similar computation for a total lift of 1,650 ft. gave a total of $135,887,000, which is an increase of $3,250,000 for a 50-ft. increase in lift. The average additional cost per foot of additional lift is, accordingly, $65,000. These estimates are merely typical. Many others, based on other assumptions, particularly as to water demands and interest rates, were made for comparison. After a careful weighing of all probabilities, a value of $65,000 per *additional* foot of head was adopted for design purposes.

Theoretically, where several lifts are involved the value of head should be computed separately for each, and the individual values used in design. If the cost of pumping at the various sites should vary appreciably, each intervening section of line would have its own control, which would determine to what extent the pumping could be done at the cheapest plant. Unless a control should occur immediately at the end of a line, the cost of pumping at each plant would control the slope for a length in each direction. In the case of the Colorado River Aqueduct, the cost of pumping at the various plants was not sufficiently different to warrant separate analysis for each plant.

Many of the factors entering into the calculation of this value in 1932 have changed. Interest rates are lower, which would increase the capitalized items. Construction costs are lower, power may cost less, and pump efficiencies are distinctly higher; all of which reduce the estimate. The important factor of future water demand is of course not definitely determinable in advance.

Part of the Colorado River Aqueduct lift (72 ft.) is accomplished by the Parker diversion dam. The economic combination of pump lift and dam, in such a situation, is found by comparing cost-of-dam and cost-of-pumping curves. Parker Dam was not designed for the primary purpose of elevating the water, but rather for regulating and clarifying the flow of the river. Incidentally, it furnishes opportunity for the development of power. Its height is limited by the location of the city of Needles, Calif., at the headwaters of the reservoir.

Indefinite or unknown value of head

If the development of power at *J*, Fig. 7, is infeasible or undesirable, and if there is no other use for excess fall at that point, the value of a foot of head above *K* becomes zero and the economic problem is altered. It is evidently desirable to use up all of the fall between *F* and *J* in conduit slope. A similar situation is encountered when the source of original supply is naturally at a higher elevation than the point of use, and where no power de-

FIG. 15—LOOKING EAST from the top of Eagle Mountain pump lift. The conduit section approaching the pumping station has been completed and covered in the foreground. Headquarters camp for Division No. 3 at the right.

velopment or pumping is contemplated.

If the conduit is of one type for its full length, with a constant cost per linear foot, it is simply given a uniform grade to consume the full available fall. However, if there are several types of section, or decided differences in the cost per linear foot along the line, an economic balance in cost must be estalished.

To do this, plat a set of cost-slope curves, as illustrated in Fig. 8; then *assume* a trial value for the angle θ and locate the points of tangency for parallel lines on the cost curves, similar points *S*, *Q*, *O*, and *M*, Fig. 8.

Apply the slopes corresponding to these points to the various lengths of conduit to find the corresponding total fall. If this fall is the same as the available drop, the assumed value of θ is correct; otherwise, assume a new value and repeat the trial. In this way, a strictly coordinated set of slopes is assured. This constitutes one of the most useful applications of the theory of economic slopes.

The slopes for that portion of the Colorado River Aqueduct between the San Jacinto Tunnel and the Cajalco Reservoir were determined in this manner, the ends of the line being fixed in elevation. As a result the tunnels in this section are 15 ft. 3 in. in diameter, rather than 16 ft., as on the remainder of the aqueduct.

In a later article Mr. Hinds will discuss the design of pressure conduits, whose economic slope and diameter presents a problem requiring special methods of analysis.

CAPITALIZED COST OF PUMPING COLORADO RIVER AQUEDUCT

Preconstruction Estimate — *Total lift* 1,600 *ft.*

Year	Estimated Water Demand sec.-ft.	Estimated Expenditure	Present Worth Factor (a) at 4¾ per cent	Present Value as of 1940
		Operating Charges		
(Prior to 1940)	....	$3,109,000	1.00	$3,109,000
1940	529	3,159,000	1.00	3,159,000
1941	564	3,546,000	.9547	3,385,000
1942	599	3,916,000	.9114	3,569,000
1943	633	4,309,000	.8700	3,749,000
		(intermediate values omitted)		
1977	1,497	5,351,000	.1796	961,000
1978	1,500	5,373,000	.1714	921,000
1979	1,500	5,388,000	.1637	882,000
1980 to 1988	1,500	5,471,000 Average	.1307 (av.)	6,440,000
After 1988	1,500	5,413,000 Annually	.1029	11,726,000
Total capitalized operating charge to year 2020				$103,163,000
		Capital Expenditures		
(Prior to 1940)	....	2,971,000	1.00	2,971,000
1940	529	1,018,000	1.00	1,018,000
1941	564	1,018,000	.9547	972,000
1942	599	1,009,000	.9114	920,000
1943	633	1,018,000	.8700	886,000
		(intermediate values imitted)		
1977	1,497	1,483,000	.1796	266,000
1978	1,500	1,442,000	.1714	247,000
1979	1,500	1,410,000	.1637	231,000
1980	1,500	1,378,000	.1563	215,000
After 1980	1,500	13,931,000	Variable	1,470,000
TOTAL PRESENT WORTH (1940) OF CAPITAL EXPENDITURES				$29,474,000
TOTAL COST OF PUMPING, 1,600-FT. LIFT				$132,637,000
Total cost of pumping, 1,650-ft. lift (similarly computed)				$135,887,000

Note (a) — Present interest rate is 4 per cent.

Stabilized Bases For Iowa Roads

Design and construction methods worked out by trial are approaching a determined practice for light-surfaced roads

IN THE VALLEY STATES west of the Mississippi a general movement is in progress to develop stabilized soil base for lighter-surfaced roads. In common, these states have large mileages and their road-building funds have to be spread thinly. They are agricultural states; heavy industrial traffic is concentrated in the cities and traffic serving agriculture does not call for heavy surfacing but does demand a surface that will provide smooth, year-around travel. The problem then is to produce a light-surface road with a high-strength element and stabilized soil base is being looked to for the solution.

In this activity, economy requires that local materials must be sought out and used as far as possible. Fine materials vary a great deal and coarse material is not distributed too plentifully. Dealing with sand, silt, loam, loess and fine gravel as the common materials in many areas has required intensive laboratory and field experimentation with investigation not yet completed. The problems of base thickness and shape of cross-section are still being worked out, while construction procedure and equipment are also in a state of trial. Withal, stabilized-base, light-surfaced roads are being built and are serving traffic. Hence design and construction practices are of interest.

The articles that follow are condensed surveys of present base stabilization in Iowa; the first, an abstract of a report to the Iowa Engineering Society and the second, an abstract of a report to the 1936 Montana Bituminous Conference. They present a brief but well-rounded account of studies in developing a new practice; incidentally, they are a reflection of the increasing influence of the developing science of soil mechanics upon the highway builder's art. —EDITOR.

Stabilized Road-Base Design

Experience over three years crystallizes into a road-wide uniformly-thick section

By V. G. Gould

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THE FAILURE in part or whole of bituminous surfaces laid in Iowa during 1930 to 1933 has been mainly responsible for the development in the last three years of stabilized-base construction.

In the winter of 1933-1934 the department of materials and tests drew up specifications for two general types of bases intended primarily to overcome surface failures. These two types are known as (1) stabilized base courses and (2) reconstructed base courses.

The stabilized base courses called for a compacted material three in. thick extending from shoulder to shoulder of the roadway and consisting of an intimate mixture of surfacing gravel and soil binder. The reconstructed base courses were subdivided into (1) edge-strengthened type and (2) full-base type.

The edge-strengthened type consisted of two V-notches, the outer edges of which were twelve ft. out from the centerline. These notches extended five ft. toward the center and were filled with coarse crushed-rock aggregate, choked with fine rock and dust and compacted by rolling. The outer edges of the notches were from four to six in. deep and feathered to zero depth at the inside edge. The full-base type consisted of the strengthened edges plus three in. of compacted crushed rock over the remainder of the 24-ft. section of roadway.

The conclusions regarding this first year's work in base construction were:

1. The stabilized-base courses were in general considered successful except that the depth of compacted base should be four in. instead of three in. and that frost-boil treatment was required in addition to the base construction for all areas seriously affected by frost action.

2. The edge-strengthened type was generally unsuccessful due to a lack of neatness in the finished work; difficulty in correcting distortions of the surfaces and of rebonding the aggregate, and instability under traffic.

3. The full-base type was considered as reasonably satisfactory, except that proper bonding of the aggregate was difficult once the initial bond had been broken.

In the winter of 1934-1935 it was necessary to set up some definite construction schedule in order to release projects for letting in the spring. Therefore it was not possible to profit greatly from the preceding year's work in formulating the base program for the coming year. However, a check of the bituminous projects revealed that failures of the surface existed generally on the outer four ft. of the 22-ft. treated section. Therefore edge strengthening with the use of gravel or crushed-stone and soil binder was adopted for practically all of the 1935 base program.

Conclusions regarding the value of edge strengthening were forcibly thrust upon us when surfacing in 1936 the projects thus strengthened in 1935. The summer of 1936 was extremely dry and it was practically impossible to secure a smooth surface on which to place the inverted penetration type of surfacing. The existing metal lying between the edges was partly and, in some instances, was entirely displaced in attempting to smooth the surface.

In surveying the finished product the highway department has tentatively committed itself to base stabilization of two definite types: (1) Stabilized gravel or crushed-stone base courses on which to place bituminous surfacing, and (2) Stabilized gravel or crushed-stone base courses for the conservation of surfacing metal.

Stabilized base construction on which to place bituminous surfaces, contemplates a minimum depth compacted of four in. with a crown for the center 24-ft. of from three to four in. The bonding medium is to be, so far as possible, soil binder from the subgrade proportioned in accordance with the desired characteristics of the finished mix. To describe more definitely the type of construction contemplated, the following brief comments are quoted from the existing specifications:

Stabilized gravel or crushed-stone base course shall consist of a dense uniform mixture of aggregate and binder soil. All the aggregate shall pass a one-in. square or 1¼-in. round sieve. Binder soil furnished by the contractor shall have such characteristics as to impart the specified characteristics to the final mixture of aggregate and binder soil. The final mixture of aggregate and binder soil shall be so graded and the prescribed constituents shall be combined in such proportions as to produce a mixture conforming to the following composition limits by weight:

Size sieve		Per cent
Passing	1.05	100
"	0.742	80–100
"	0.371	70– 95
" No.	4	55– 80
" "	10	40– 65
" "	40	22– 45
" "	270	10– 25

The fraction passing the 270 sieve shall not be more than two-thirds of the fraction passing the 40 sieve. The fraction passing the 40 sieve shall have a plasticity index between six and fourteen and the liquid limit of this fraction shall not exceed 35 per cent.

Stabilized Base Construction

Comment on current methods and equipment that are finding favor in the production of stabilized road bases

By A. E. Stoddard

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COMMON PRACTICE in states of the Middle West includes thickness of base from three to twelve in. Iowa is probably using the thinnest base of all, since it is stabilizing about 2,000 cu. yd. of aggregate per mi., most of which is used in strengthening the edges of the surface to be treated. The net compacted thickness will probably not average more than three in. However, prior to placement of base, portions of extremely weak subgrade are given frost-boil treatment.

This frost-boil treatment generally consists of placing a porous layer of rock or gravel which will interrupt the capillary flow of water. Drainage is provided for these porous layers. If at any time the drainage fails to function, the porous layer will become a reservoir which will supply an excess of water to the subgrade adjoining the treated area. It is the writer's opinion that an impervious layer, in which it is not possible to have sufficient capillary flow to cause instability, will be more effective than a porous layer which may act as a reservoir for water. To this end it would be much better to increase the thickness of the stabilized layer of base course rather than to embody the present method of frost-boil treatment.

The width of this type of construction is generally greater than for rigid pavements; a 20-ft. concrete pavement is standard but the stabilized base is usually constructed to widths of 22, 24 and 26 ft. Theoretically, from the standpoint of design, the base should exceed the width of surface to be traveled by at least two times the depth. Extra width also tends to avoid traffic wear on the unprotected edge of the surfacing; thickening of the edges will also add considerable stability to the surface.

Where the new surface is being built on top of an existing surface, it is necessary to use side forms to secure consolidation of the mixture at the edges and at the same time maintain proper riding qualities of the surface. Where the base is built in trench section the earth shoulders furnish lateral support during consolidation. The trench section somewhat restricts the operations of preparing and mixing materials on the road surface but does not affect placement of plant or pre-mixed surfaces.

The stabilized soil-sand-gravel surfaces are accurately proportioned mixtures of materials of every size from the customary maximum of one in. to colloids. Prompted by the economy of using all available materials, common practice has used the mineral aggregate from the road surface and the subgrade soil for the binder. Material removed from the road surface must be made as uniform as possible in quantity and character to secure a uniformly finished mixture. The quantity is most easily controlled by a portable orifice or gopher trap which will produce a uniform cross-section of windrow. Other materials added to the mixture must also be proportioned in the same way. Since laboratory tests results are reported on a weight basis it is necessary to convert the data to volumetric proportions, using the unit weights of materials as placed in the windrow.

Preparing binder

Soil binder must be thoroughly pulverized to function properly in the mixture. Equipment for this purpose will vary considerably with different contractors. When the clay is pulverized on the roadbed the disc, the tooth harrow and other farm equipment for breaking clods and preparing the seed bed will serve. One of the old drags made of three planks lapping each other about three in. is quite an effective pulverizer. One contractor has used what is known as a roto-mix, which consists of a semi-cylindrical hood over the mold board of a motor patrol, with a single shaft carrying paddle wheels mounted in front of the blade and driven by a separate power unit. This machine was a very effective pulverizer but on windy days caused some loss of dust. A light roller is also effective in the initial stages of pulverizing.

Various other methods have been used. When the soil is not pulverized on the roadbed, the clay may be partly pulverized in the pit before removal to the road if the deposit is dry enough. In such an operation the pit would probably extend over a considerable area and a thin layer of the material could be thoroughly disked and given preliminary pulverizing by any of the equipment mentioned above. In some projects in Minnesota the soil binder prepared in this manner was then passed over shaker screens to remove the oversize and the finer sizes transported to the road where they are placed on top of the gravel to complete the pulverizing and mixing. One manufacturer has developed a clay shredder which, without drying, breaks up the clay quite fine by passing it between two rolls which operate at vastly different speeds. The shredded clay is then passed through a proportioning device which delivers it to the mixer with the gravel in the desired proportion.

In any of the pulverizing operations, good drying weather is absolutely essential for without it the clay cannot be sufficiently pulverized. On one project using a plant-mixed material, the clay was delivered dry and completely pulverized from a commercial brick-and-tile factory. One or two contractors have proposed wet mixing as in the wet process of cement manufacture, but to my knowledge none of them has tried this method. Clay retains its moisture and loses it slowly so that the reduction of moisture content in mixtures which are too wet would be much more difficult than raising the moisture content of mixes which are dry.

Originally it was recommended that the soil be pulverized until 90 per cent would pass the eight-mesh sieve. At

this point, however, the soil becomes practically fluid and there may be considerable loss because of the dry material flowing off the road surface or being blown away by the wind. Present Calcium Chloride Association specifications require pulverization only until 80 per cent of the soil will pass the four-mesh sieve. These limits were set because it was found that particles passing the four-mesh sieve were usually broken down sufficiently during the mixing with the aggregates. However, with proper equipment and but very little more work, pulverization until at least 90 per cent passes the four-mesh sieve may be secured and this is felt to be a more desirable limit.

The presence of a small amount of moisture in the soil renders it much more easily pulverized. Also the incorporation of some sand in the early stages of pulverizing helps to break down the small clods which, when thoroughly dry, act like so many ball bearings. When soil is sufficiently pulverized it is mixed with the aggregates by blading and disking the windrow in a manner similar to mixing bituminous-treated surfacing materials. Thorough mixing will continue the pulverizing and reduce and distribute the soil to the desired condition.

Mixing processes

When the materials from the road surface are not incorporated in the mixture by proportioning, drying and mixing may be done on the road by bringing on all the ingredients in the desired proportion, or by pre-mixing the materials. In a few instances deposits have been found which, with but slight alteration in excavating the material, will conform to the requirements for the finished mixture. The mixing may be accomplished by the same methods and with the same equipment used for mixing concrete, but more efficient mixing is accomplished in the pugmill type mixer.

Whether the material will be mixed on the road or pre-mixed will be influenced by several factors. When either the soil binder or the aggregates or both are available in the existing road surface, it will generally prove more economical to mix the material on the road surface. The thickness of surfacing to be placed will also influence the selection of road or plant mix. About 2,000 cu. yd. of materials per mi. of road is all that can be conveniently handled on roadways of ordinary width. Where the quantity involved is greater than this, it should be placed by completely separate operations in two or more layers.

Plant mixing is particularly advantageous where available deposits require but little treatment to meet the required composition; also in city work where the shade from adjacent trees and buildings would obstruct the drying and where the dust from pulverizing would be a public nuisance. It is also advantageous in working the irregular areas of street intersections. In plant mixtures the moisture is also added at the mixer so that the mixture is ready to compact when delivered on the road.

Moisture content

In the final stages of the mixing process, sufficient moisture must be added to put the mixture in a proper condition. The moisture should be sufficient to raise the portion of the mixture passing the 40-mesh sieve to the plastic limit. The moisture content has a very definite effect on the density which can be secured by any given method of compaction. In either too dry or too moist a condition the mixture cannot be consolidated as well as at just the right moisture content. This effect can easily be observed by checking the unit weight of samples compacted at various moisture contents. Curves of the relative densities for various moisture content behave exactly like mortar-voids curves for cement mortars.

The desired moisture content must be maintained during compaction. To prevent the subgrade from taking moisture from the mix the subgrade should be sprinkled and the mixture placed while the subgrade is still moist.

Consolidation of the mixture is an important item. Again the procedure must be varied to fit the equipment to be used. In general the base course should be placed in layers not exceeding three in. thick, where smooth, steel-surfaced rollers, or pneumatic-tired rollers are used for compaction. The pneumatic-tired rollers seem to be more efficient than the smooth, steel-tired rollers in compacting the surface, but a surface finished with the pneumatic-tired rollers will not be as smooth as one finished with a steel-tired roller. Mixtures with the higher plastic limits at certain moisture contents tend to stick to steel rollers, but may be easily compacted by the use of pneumatic-tired rollers.

With a sheepsfoot or tamping roller a deeper layer of material can be compacted because this roller consolidates the course from the bottom upward. The depth of layer should not be as great as the length of prongs or feet, because the pressure is reduced by greatly increasing the bearing surface. Too plastic a mixture would probably fill up a sheepsfoot roller by adhering to the feet.

I have recently seen a roller used by the Portland Cement Association on stabilization experiments. This roller is composed of about twelve cast-iron wheels, each with a rolling face only 2½ in. wide with a space of about 3½ in. between them. The wheel is solid and for a radial distance of about ten in. from the face the thickness increases, giving a trapezoidal section. The roller is equipped with surface cleaners and bayonet cleaners between wheels. Also in the rear frame is a rake which can be adjusted to smooth out the ridges left by the rolls.

From laboratory studies it is apparent that with mixes of uniform moisture content, the degree of consolidation effected will depend upon the amount of work done, or the number of passes of the roller.

To insure satisfactory compaction it will be necessary to compare results secured by field methods with results obtained by some standard method of compaction. A convenient basis of comparison is compacting by tamping or ramming the material into a mould such as is used in the Proctor method for checking the consolidation of soils and earth dams. It is not possible to use the Proctor needle in checking consolidation of mixtures containing gravel and stone. For such mixtures it is not usually possible to remove intact a specimen from the road surface. The unit weight of the compacted surface can be checked with a fair degree of accuracy by measuring the hole from which the sample has been removed. This can be done by measuring the quantity of a liquid, such as lubricating oil, required to fill the hole. Water may also be used for this purpose by pouring it inside a very thin rubber sack. Dry sand has also been used.

The use of salts such as calcium chloride or sodium chloride to maintain a more uniform moisture content, has been highly recommended by companies with these materials to sell. When the base or road surface is to be left uncovered, or is to be used by traffic for a period of times as when the surface is compacted by traffic, it is essential to retain proper moisture content. Either sodium or calcium chloride are effective in retaining moisture during handling and compaction.

Indiana Narrow Bridge Program

WITHIN FOUR YEARS the Indiana State Highway Commission has widened 3,000 small bridges and culverts on the 9,000-mi. state system but there still remain 2,000 additional narrow structures which have a clearance of from 11 to 20 ft. They claim many lives and cause some of the most tragic accidents. Replacement cost is estimated at 25 to 30 million dollars, which means that the work must be spread over a number of years. This bridge work is part of the shoulder-widening program initiated in 1933, on which 1,800 mi. of right of way have been widened.

FIG. 1—CUSTOM BUILT for definite manufacturing operations, this new plant provides 60,000 sq. ft. of space that may be enlarged by one-half.

Keying Factory Design To Production Requirements

Bay widths, ceiling heights, utility services, wall and floor materials and lighting in new plant of Liquid Carbonic Corp. have positive relation to manufacturing operations to be served

By G. L. Howse

Engineer, The Liquid Carbonic Corp., Chicago, Illinois

RECOGNIZING that industrial buildings are as much tools of production as the machinery itself and that they should be designed accordingly, the Liquid Carbonic Corp. approached the design of a new bottle washer assembly building at its Chicago plant by first analysing production needs. A thorough study was made of the particular functions to be carried out in the new unit and of the working conditions that were desirable for efficiency. This involved a survey of plant production processes in both present and proposed bulidings. Only after the production department had decided upon its final requirements as to operating facilities and layout did the engineering staff take up the work.

The actual design work was considerably simplified by the definite wants and standards called for by the production department. It consisted primarily of finding the most economical structure—from the long-range viewpoint—to carry out the expressed wants. The final structure is a one-story unit 500 ft. long by 120 ft. wide divided into two 60-ft. bays. One bay with a clearance of 40 ft. beneath the roof trusses serves the final assembly process. The other with a clearance of only 30 ft. serves for various sub-assemblies and for stock space. With the exception of a timekeeper's office and a small compressor room, the entire 60,000 sq.ft. of floor is live space, since locker rooms and offices are located on mezzanines. The foreman's office, large enough to accommodate his office staff, is located on a mezzanine in the center of the building; it has clear glass partitions giving a full view of the entire shop.

Building structure

Earlier construction in the vicinity revealed very poor bearing values for the soil, and extensive soil investigations and test loadings indicating that piling should be used under the new building. Cast-in-place piles were driven under the heavier machinery foundations and in clusters of three on 20 ft. centers at the column locations. Concrete caps were poured on these pile clusters to support the steel columns of the frame. Concrete beam framing between the caps carry the base of the exterior walls which consists of a 5 ft. lift of brick. The remainder of the wall consists of cement-asbestos siding and steel sash. About two-thirds of the wall area is glass. The cement-asbestos siding was used because of its insulating value and because its natural finish requires no paint maintenance.

The roof is supported by 60 ft. span steel trusses in each bay, spaced on 20 ft. centers. The inner ends of the trusses are jointly supported by a single row of columns placed between the crane runway columns for each bay. The roof consists of 2-in. gypsum plank poured in place and covered with a tar and gravel roofing. In the high bay, where the heavy assemblies are made, a 9-in. reinforced concrete floor was laid while a 6-in. floor was considered sufficient for the low bay. All flooring is laid over a consolidated fill of blast furnace slag. Since the building floor is subject to only minor changes in temperature, expansion joints were only laid lengthwise of the building and around the machinery foundations. The roof is pitched toward the center of the building; downspouts being carried down the interior columns. In this way, one 12-in. storm sewer line accommodates all the downspouts and the floor drains; the sanitary sewer parallels it.

In spite of the high insulating value of the 2-in. gypsum roof plank and the cement-asbestos siding, a heavy heat loss occurs because of the large glass area and the frequent opening of the doors. The heating system installed uses high pressure steam in six unit heaters. Steam is delivered to the

building at 200 lb. and is reduced to 60 lb., supplying three 1,000,000 B.t.u. units and three 600,000 B.t.u. units. These units are floor mounted in the center of the building, with vanes directing the hot air toward the walls at a height just above a man's head. All condensate is trapped and returned to the boiler room. All lines are thoroughly insulated and expansion is cared for by expansion loops and bends.

Careful lighting design

Particular attention was given to the lighting system since daylight is often insufficient in the winter months and since considerable night work was required. From earlier tests that had been made around the shop, it was realized that there is a definite relationship between the quality of workmanship and the quality of the lighting. And the lighting requirements were special because the building is used for the assembly of large tanks, often 20 ft. high, and 10 to 15 ft. wide and 20 to 30 ft. long. With several of these tanks under construction at one time, it can readily be seen that the lighting must be properly spaced and of sufficient intensity to avoid dark aisles on the floor. Furthermore, much of the assembly work is on vertical or semi-vertical planes within the tanks, and the mounting height of overhead units was limited by the overhead cranes. Hence, the problem was to provide vertical and horizontal lighting of sufficient intensity, from a high ceiling, and eliminate the possibility of shadows between any reasonabl line-up of tanks.

Earlier experiments with the 400-watt bulb-type mercury vapor lamp in other plant departments had demonstrated several advantages for this type of unit among which were about double the amount of light as from an incandescent lamp for the same wattage and a quality of light apparently easy on the eyes in revealing detail. Workmen, after working under mercury vapor lamps for a few weeks, were very much in favor of them. Consequently it was decided to use mercury vapor lamps in the new assembly building.

Two objections have been raised to the mercury lighting:—there is a noticeable amount of color distortion and with the bulb-type units the light requires about 10 min. to come up to full brilliance. The first objection was not of concern since no particular color work was involved. However, as a definite safeguard against production delay due to current interruptions, it was decided to use half incandescent and half mercury vapor lamps. Tests of this combination also showed a desirable "daylight" color balance.

Several experiments were made to determine the proper arrangements of the units. With the trusses dividing the areas into panels 20 ft. wide and 60 ft. long, and with two bays of different height, there were definite physical limitations on the spacing. Furthermore, the type of unit used would affect the spacing. A high-bay concentrating unit was finally selected as it gave the greatest intensities on the working plane near the floor combined with sufficient spread to blend the two different colors of light. In the high bay the lights are arranged four per panel across the width of the bay, with alternate panels of mercury and incandescent offset so that there are in effect eight channels of light down the length of the building. Assuming eight lights in one row, equal distribution would require nine spaces of 6 ft. 8 in. on a 60-ft. width. In the first row of lights installed, the spacing from the wall is 6 ft. 8 in. and then four spaces at 13 ft. 4 in. In the next row, the spacing (also from the wall) is 4 spaces at 13 ft. 4 in. and then 6 ft. 8 in. There are thus 4 lights per panel, but 8 rows of lights down the length of the room.

The same idea was used in the low bay, but using three lights per panel. The spacing there, starting with the center where the high bay ends, is 8 ft. 7 in., 17 ft. 2 in., 17 ft. 1 in., 17 ft. 2 in., to match the first row in the high bay, and 17 ft. 2 in., 17 ft. 1 in., 17 ft. 2 in. and 8 ft. 7 in., to match the second row in the high bay. The mercuries and incandescents are kept in the same rows across the building.

With this spacing and type of unit, the resulting light on the working plane is shadowless and approximates daylight providing excellent working conditions. Tests in the high bay show

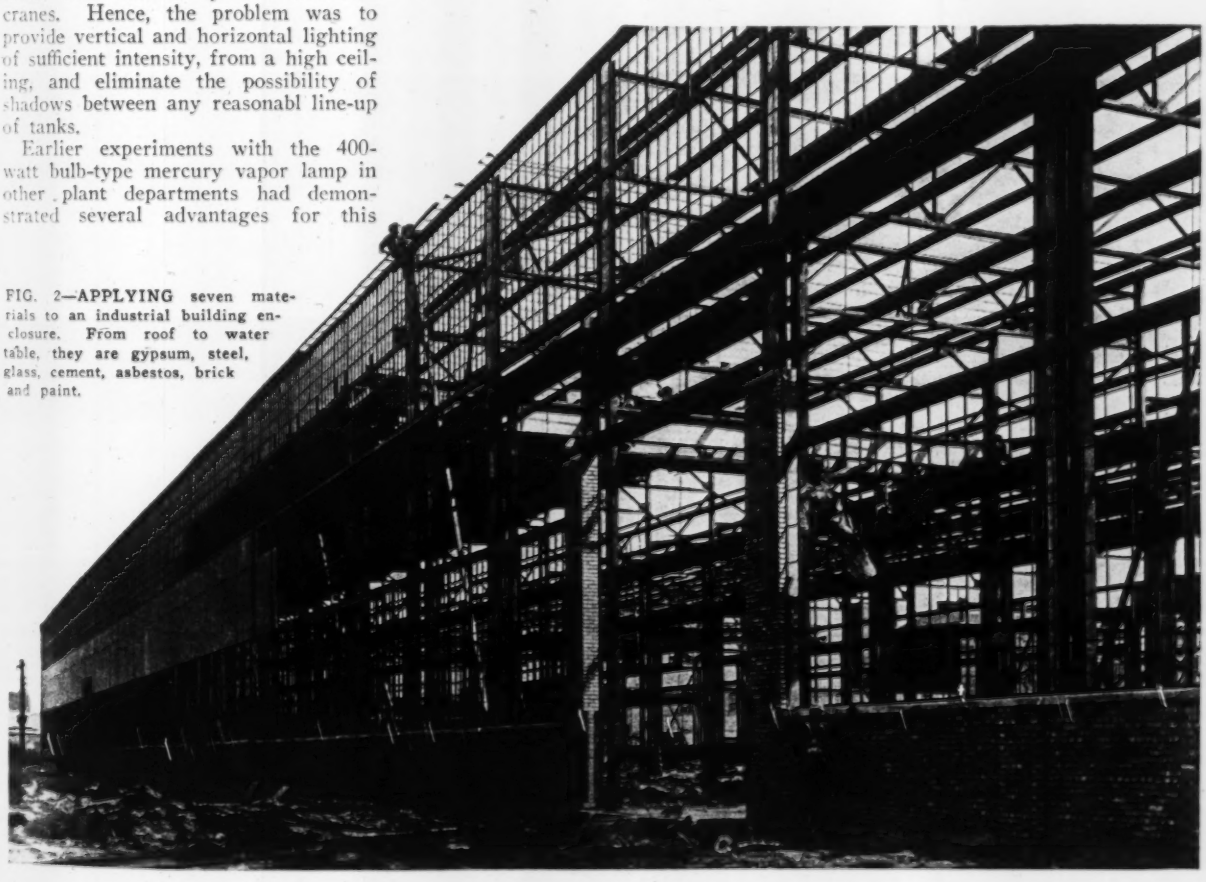


FIG. 2—**APPLYING** seven materials to an industrial building enclosure. From roof to water table, they are gypsum, steel, glass, cement, asbestos, brick and paint.

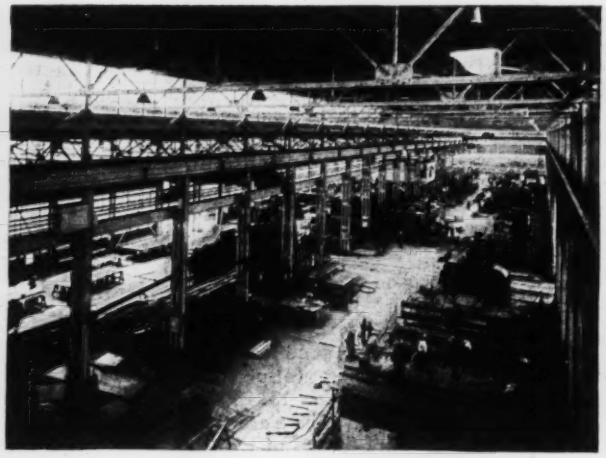


FIG. 3—BY DAY OR NIGHT exceptional illumination is provided for the bottle washer assembly operations. Some 75 per cent of the wall area of the building is glass and for artificial light, mercury vapor and incandescent lamps are used in alternate rows.

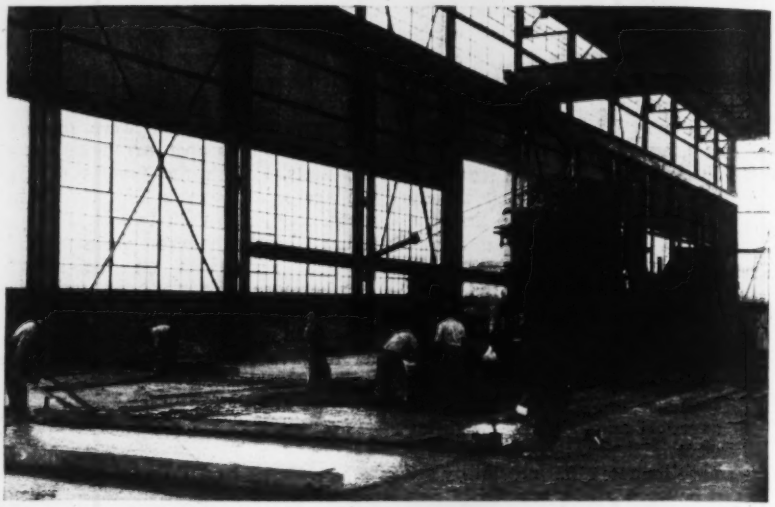


FIG. 4—ROAD PAVING PRACTICES and equipment lay the 6- and 9-in. floor slabs in the new plant of the Liquid Carbonic Co.

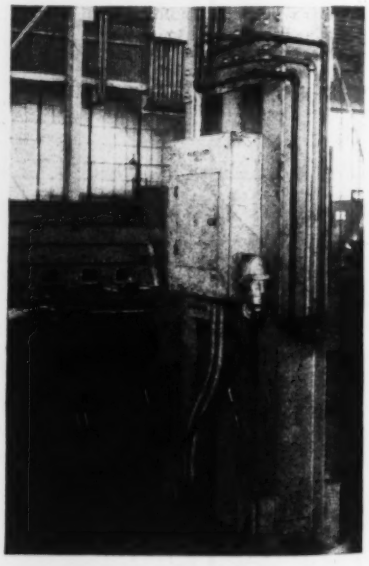
initial and final intensities of 23 and 20 ft. candles, respectively, on the work plane at the floor 38 ft. under the units, with a vertical intensity of 7 ft. candles. The wattage is 1.94 watts per square foot. In the low bay, 28 ft. under the units, using 13 panels of 500-watt incandescents and 12 alternate panels of 400-watt mercuries, the initial and working intensities are 19 and 16 ft. candles, respectively, with 7 ft. candles on the vertical plane. The wattage is 1.13 watts per square foot. Both the vertical and horizontal intensities rapidly increase toward the unit, so that the fine assembly work on the upper part of the tanks is carried on at even higher levels.

In each bay the lights are switched from the interior columns toward the outside walls, so that the maximum use may be made of all available daylight. The incandescent lamp reflectors are of a size to take a 1000-watt lamp, so that it is estimated the working intensities may be stepped up from 20 to 24 and from 16 to 20 in the high and low bays respectively. Particular care was taken in wiring to provide for no excessive line drops as the mercury lamps especially suffer a noticeable loss of illumination at lower voltages. Visors are provided on the exterior row of lights in the high bay to give a greater concentration of light on work benches arranged along the wall, and to avoid excessive loss of light out of the windows. All interior steel work, both columns and partitions, has been painted with aluminum paint as the best compromise between a good reflecting surface and a surface easy to maintain.

Other service facilities were also engineered with long-range economy in mind. Gas, water and compressed air outlets are provided at alternate columns. Four light-service electrical outlets are provided at every column for small drills and the like. Heavier service outlets are installed on alternate columns for larger motors, welding machines, etc. These outlets give a flexibility to the layout to care for probable future changes and also are in line with the tendency toward more portable electrical assembly tools. Stationary equipment is served by underfloor conduits, with additional conduits charted for future machinery.

The building is served by two railroad tracks, one at each end of the building, so that equipment may be unloaded or loaded within the shelter of the structure. A concrete drive leads up to two truck doors. All six openings are equipped with rolling steel doors,—the greater use of the truck doors warranting electrical operation. A storage yard extending along one side of the building is reached by both railroad tracks and is served by a crawler crane. The shop is served by four electric overhead cranes operating the length of the building. In the high bay are two 15-ton cranes, one having a 1-ton auxiliary hoist; in the low bay are one 5-ton with a one-ton auxiliary and one 3-ton.

FIG. 5—SOURCE of SUPPLY at one of the interior columns. Here gas, water and compressed air are available as well as electrical outlets both for lights and for tools such as welders or portable drills.



Attention has also been given to facilities for the workmen. Individual lockers are provided in two mezzanine locker rooms, one at each end of the building. In addition to toilet facilities, two 54-in. circular wash basins are provided in each locker room. The capacity of these locker rooms may be doubled by adding a second story to the mezzanines. Four drinking fountains on the main floor provide cool drinking water at all times.

Throughout all the construction flexibility has been emphasized. In so far as possible every attempt has been made to keep the building in step with production changes. The structure itself may be enlarged by the addition of a third 60-ft. bay alongside the present high bay in the space now occupied by the storage yard. Lighting intensities may be increased by about 25 per cent without additional wiring or excessive line drop. Service facilities are available for more portable equipment. The power load may be increased when additional stationary or portable machines are required. The transportation facilities are extremely flexible. The result is a building with pleasing design that may reasonably be expected to keep in step with production for some years to come—to continue to serve, rather than to confine, production.

Considerable credit is due to the several suppliers who aided by their advice and equipment; to the architect, J. J. Novy, Chicago; and to the contractors, Kaiser-Ducett Co., Chicago.

Concrete Rigid Frame Span of 146-ft. Features Park Bridge at Kenosha

By Hugo E. Bothe
Civil Engineer, Kenosha, Wis.

A RIGID FRAME span 146 ft. long from center to center of piers, believed to be the second longest in the United States at present, is a feature of a three-span concrete memorial bridge completed in August, 1936, in Lincoln Park, Kenosha, Wisconsin. While intended primarily for pedestrians to pass across a park lagoon, this bridge is designed to carry trucks and other park maintenance equipment equivalent to an H-10 loading. The roadway is 10 ft. wide between curbs.

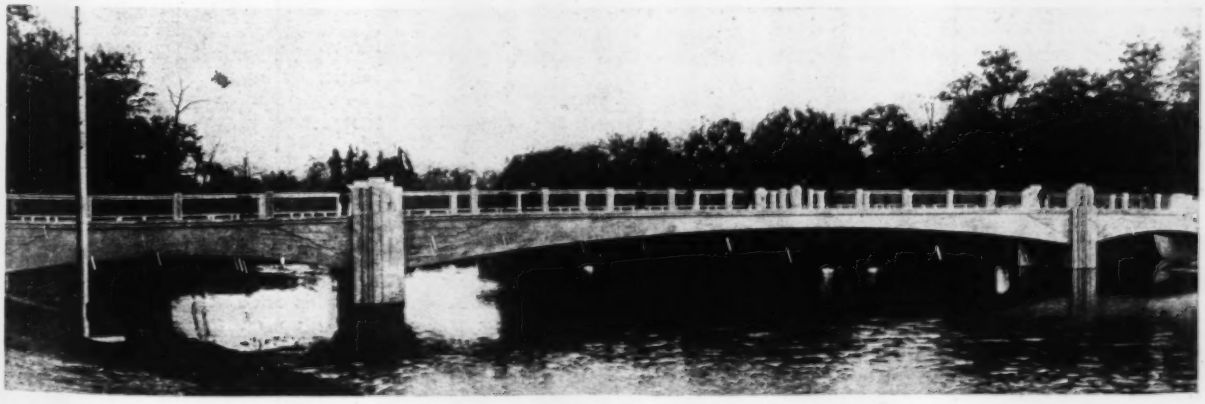
The problem was to get an attractive structure which would have sufficient height above the level of the lagoon at the springing line and the lowest possible elevation of deck to permit safe boating and ice skating. An economical design solution proved to be a long rigid frame center span, with 43½ ft. end spans simply supported. The foundations rest on hard blue clay about 10 ft. below the bottom of the lagoon.

The deck slab of the rigid frame span is 6½ in. thick at the gutters and is crowned 1 in. It is supported on two ribs 9 ft. 4 in. apart, this arrangement giving a lighter and more economical design than the alternative of three ribs. The two ribs are 1 ft. 4 in. wide and vary in depth about 3 ft. 1 in. at the crown to 7 ft. 3 in. at the springing lines. Five transverse stiffening beams are provided. As a means of providing sufficient strength, a soffit slab is used, making the structure a hollow box girder for a distance of 11 ft. out from each center pier. From the 11-ft. point toward the center the soffit slab narrows down, ending at the nearest transverse stiffener as shown in the sectional plan view.

For appearance and structural reasons the piers were made 7 ft. wide. Tension reinforcement from the top of the deck span is carried down the outside face of the piers and into the footings, no attempt being made to secure hinge action at the top of the footing. Hinge action, however, was provided at the toe of the footing.

The end spans each consist of a deck slab supported on two girders arched to harmonize with the center span. Cork-filled expansion joints 1½ in. wide are provided at the piers and 1 in. cork-filled joints at the abutments. The springing line at the pier extends below the seat of the girders. The expansion joint below the seat is concealed to give the appearance of a continuous structure, by notching the girders into the piers. Bronze expansion plates are provided at the abutment ends.

A CENTER SPAN of rigid frame type combined with simply-supported side spans to produce an integrated unit of pleasing appearance.



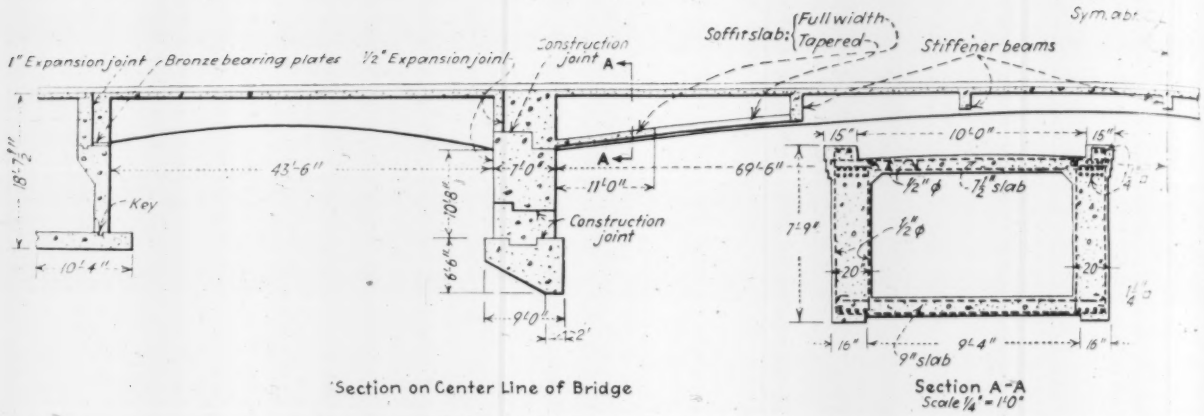
Architectural design

As indicated in the accompanying photograph, the finished bridge presents a striking appearance. The rigid frame design permitted a remarkable lightness of deck (the depth at center being only about 1/45 of the span) without sacrificing strength. The deck is cambered 18 in. in an over-all length of 245 ft.

The hand railing consists of standard extruded heat treated aluminum members set in concrete posts. This open design adds to the effect of lightness. Perhaps the principal means of obtaining an appearance of strength is in the design of the pylons. Vertical reveals or offset lines of the pylons, together with the restrained wing motif, give the bridge a distinctive modern appearance. The wingwalls are of novel design, stepped, and given vertical offsets to harmonize with the piers.

Construction

Forms for placement of the deck were supported by two lines of 8x8 in. posts 14 ft. apart, and intermediate posts, resting on long 6 by 10 in. mud sills all



STRUCTURAL DETAILS of a two-rib 146-ft. span, concrete rigid frame bridge designed for one lane of H-10 loading.

thoroughly braced. Sheathing was bent to the shape of the intrados. By temporarily draining the lagoon more satisfactory bearing conditions were obtained for the falsework and construction was expedited. Much of the form work was fabricated in an adjoining building and brought to the job in sections. The architectural detail called for unusually careful forming and much of the success in getting a fine looking job was due to the careful supervision of the WPA force assigned to form fabrication and erection.

Concrete was placed in accordance with rigid specifications which provided for careful control of water content and frequent change of the mixture to obtain a maximum workability with materials of varying gradation and moisture content. Careful attention to workability and careful spading enabled the development of high quality concrete free from honeycombing. In addition to spading, all of the concrete was vibrated. Field cylinders were tested to as high as 4240 lb. per sq.in. ultimate strength for abutment and wing-wall concrete and 7490 lb. for concrete in the deck.

Acknowledgments

This bridge, a WPA project, was built by the department of parks and city planning, Kenosha, Wis., Floyd A. Carlson, director. The writer was the designing engineer; Charles H. Whitney, consulting engineer; Frank Vilen, surveyor; L. J. Gallager, superintendent of construction; and Floyd H. Pedley, assistant superintendent.

Construction Costs of Cotton-Reinforced Asphalt

Methods and cost of constructing a cotton fabric reinforced armor coat bituminous road surface

By Leon Corder

Project Engineer, Missouri State Highway Department, Van Buren, Mo.

THE USE OF COTTON FABRIC in bituminous road construction has the advantage, it is claimed, of giving a long-sought reinforcement to that type of surface which will reduce the amount of raveling and the formation of chuck holes in the driving surface, and of cementing the surface with a seal which more completely prevents the infiltration of water and its resultant winter damage. While it is rather early in the life of most roads of this type to reach definite conclusions, preliminary observations indicate that the above claims have some basis in fact. Experiments with this type of road as carried on by several of the highway departments in this country, as well as in England (with jute) would seem further to indicate the above benefits.

The cotton fabric used on Route 60, Shannon County, Missouri, was of three grades: Grade A-1, having 12 picks and ends per in., and weighing 5½ oz. per sq. yd.; Grade B-1, having 9 picks and ends per in., weighing 4¼ oz. per sq. yd.; and Grade C-1, having 6 picks and ends per in., weighing 3¼ oz. per sq. yd. The figures for picks and ends, and for weights, are close approximations. These three grades were placed on three test sections, arranged so as to permit future observations, and, for the most part, constructed in exactly the same manner.

Construction procedure

The entire road was swept clean by a rotary power broom, supplemented to some slight extent by hand brooms. As the existing surface consisted of ordinary surfacing river gravel which had been plowed into the roadway in an effort at base stabilization, there was a good firm foundation, but the weather preceding this construction had been so dry that some of the larger rocks in the subgrade were exposed by traffic that had fanned out the finer aggregate around them. This latter condition existed mainly within the central 8 ft. of the driving surface.

The roadway was then primed with a TC-2 tar primer (specific gravity of 1.1634 to 1.1647) at the rate of 0.3 gal. per sq. yd. The temperature of application averaged 160 deg. F. This prime coat was put on for a 22-ft. width, and allowed to cure for about 5 days. Rain on two days of the curing period delayed the start of the next phase of the work, and was a factor in lengthening the time of curing, although the entire project was primed before any effort was made to start the fabric course.

A light tack coat of 200-250 penetration asphalt (at 330 deg. F.) was applied then, and the fabric placed directly upon it. The rolls of fabric as used were 7½ ft. in width, and contained from 150 to 330 lin. yd. The tack coat was applied at the rate of 0.05 gal. per sq. yd. for a 20-ft. width, and the fabric, by lapping 15 in., also gave a 20-ft. width. Immediately following the placing of the fabric, in the case of the Class A-1 and Class B-1 (fine and medium) sections, an application of 0.25 gal. per sq. yd. of the same type of asphalt was distributed, with the distributor running directly over the freshly placed fabric. However, in the case of the Class C-1 (coarse) section, this could not be done as the fabric picked up on the distributor wheels. Consequently a very thin spray of pea gravel was placed on the fabric, after

which no difficulty was experienced. In all three cases, the second application of asphalt was for the same amount (0.25 gal. per sq. yd.)

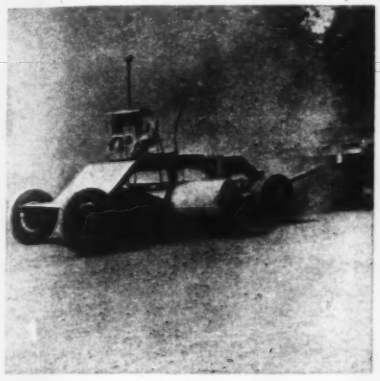
It was very evident that the finer mesh (Class A-1) fabric absorbed considerably more of the asphalt than the coarse mesh (Class C-1). This difference was also noticeable when the final blot course of pea gravel was placed. The pea gravel, in the case of the Class A-1 and the Class B-1 (fine and medium) fabrics, was applied at the rate of 25 lb. per sq. yd. The Class C-1 (coarse) fabric section, however, having already received about 7 lb. per sq. yd., was restricted to 18 lb. on the final application. Whether due to the two separate applications, or to the fact that it absorbed less asphalt, it is difficult to say; the fact remains, however, that the Class C-1 section retained more pea gravel under traffic than either of the other two sections. It would seem probable that both factors could be accepted as having some effect in this case.

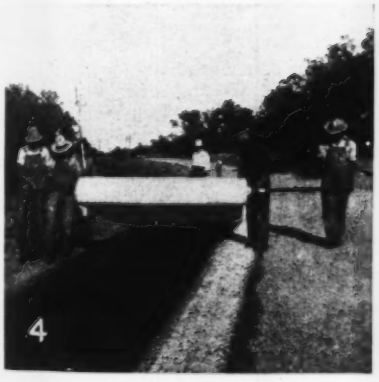
When spread, the pea gravel was distributed evenly over the full 20 ft. of roadway width by hand brooms, and then rolled with a three-wheel 5-ton roller. Each day the preceding day's work was re-rolled, and where necessary a small amount of brooming by hand was performed. The operation of re-rolling, taking place as it did, while the roller was waiting until the day's work was ready, was relatively inexpensive to contractor and undoubtedly helped.

Labor and cost

The average daily force, during the placing of the fabric, consisted of a superintendent, one foreman, two distributor operators, one roller operator, six truck drivers (with trucks, one for hauling fabric and other materials, five for hauling pea gravel), and twelve laborers. Exclusive of the five men (with trucks) engaged in hauling

CONSECUTIVE OPERATIONS IN BUILDING A COTTON REINFORCED BITUMINOUS MAT ROAD IN MISSOURI—1. Brooming off old road to remove surplus gravel and dust. 2. Spraying broomed surface with tar. 3. Spraying asphalt tack coat to stick the cotton cloth in place. 4. Unrolling the cotton cloth onto the tack coat. 5. Cotton cloth in place. 6. Spraying the cloth with hot asphalt. 7. Sprinkling pea gravel on the treated cloth. 8. Rolling the gravel into the coated cloth. 9. The completed road.





gravel, which was hauled at 4 c. per ton mile for an average haul of 16 mi., the drivers being paid 30 c. per hour, an average of 45 sq. yd. of completed fabric section was completed per man hour. This figure includes tacking, spreading, loading and hauling fabric, unloading and brooming pea gravel, making second asphalt application (0.25 gal.), rolling and supervision. No effort has been made to include here the cost of priming or sweeping, but rather to indicate the distribution of cost on that portion of the construction work affected by the cotton fabric. The cost of gravel haul was not included in the distribution because of the great difference in lengths of haul experienced on different projects. However, the actual unloading and spreading time is included, since members of contractor's surfacing force were engaged in that phase of the work.

For each dollar going into the expense of the actual work of constructing the above phase, the following distribution of costs was found to exist:

Supervision	$0.204
Distributor labor	0.102†
Loading fabric	0.013
Hauling fabric	0.025
Spreading fabric	0.079
Unloading and brooming pea gravel	0.345
Rolling	0.028
Flagging traffic	0.194*

† Only labor of operating the distributor is included.

* Short detours were used, but due to the speed of the work no permanent system for handling traffic was available. Over some sections one-half of the road was completed at a time, one way traffic being flagged through. This item of expense would have been the same if fabric had not been used.

The Missouri Petroleum Products Co. of Clayton, Mo. constructed the road. Wm. H. Guhman, general manager for the company was in active charge. The labor, for the most part, was local.

Hot Well Water Cooled for Use In City Distribution System

Water at 110 deg. F. from a flowing well at Riverside, Calif., is cooled to 85 deg. F. by evaporation process before going into city system

SIX YEARS AGO the city of Riverside, Calif., added to its water supply system an artesian well which produced 2,000 g.p.m. The water was in all respects up to standard requirements except that its temperature was 110 deg. F. Part of the flow from this well was put into the city system at first along with cool water from other wells but the result was to raise the average temperature of the entire water supply to an objectionable degree. So many complaints came in from consumers that an arrangement was effected whereby cold water from an irrigation district was supplied to the city in exchange for the hot well water. This arrangement continued for some years until recently the city decided to employ an evaporation process to cool the hot water sufficiently to permit of using it in the city system. This has been done with entire success by the means described in the following amplification of the brief description published in *ENR* Dec. 24, 1936, p. 892.

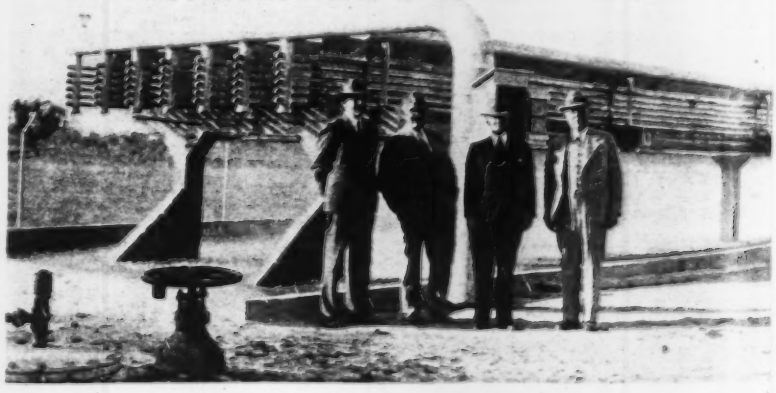
Riverside has a population of about 33,000. The city's maximum water demand is about 12,000 g.p.m., the average is about 4,500 g.p.m. and the minimum 2,250 g.p.m. All of the supply comes from wells and with the one exception the temperature of the well water is quite satisfactory for a potable supply. The hot well is 965 ft. deep and has a 20-in. perforated casing. Two other wells in the same vicinity 1,100 ft. deep have normally cool temperatures.

When the hot well was drilled some 6 years ago it developed about 2,000 g.p.m. and this flow has not materially diminished since nor does it change much from season to season. At the surface, with the outlet valve closed, the well develops a static head of 35 lb. per sq.in. When flowing freely the pressure is insufficient to force the water into the city's system. Since pumps had to be used for this purpose, forcing the water through a cooling system before putting it in the city mains was simply a matter of providing additional pump capacity.

A cooling system was built, designed on the principle of evaporating water in contact with tubes containing the hot water. A concrete basin 25x175 ft. in plan with walls 12 in. high was built on the ground near the well. Extending the length of this basin and some 6 ft. above it are 42 thin galvanized iron tubes 2 in. in diameter arranged in seven vertical tiers of six tubes each. These cooling tubes are served at one end from a 12-in. header bringing the hot water from the well via a booster pump. At the other end the tubes discharge into a 12-in. header leading to the city mains.

The circulating water is taken from the hot well and goes first to the concrete basin in which float valves maintain a depth of about 4 in. From two sumps in the concrete basin, pumps circulate the cooling water so as to keep the surface of the cooling tubes covered with water. The transfer of heat from the tubes to circulating water plus evaporation cools the well water in the tubes. There are two pumps each with a 1,200-g.p.m. capacity delivering to V-troughs above the top of each tier of 2-in. tubes. From this source water from the circulating system continually trickles down over vertical tiers of tubes. Below the tiers is a mesh of ½-in. screen set about 5 ft. above the surface of the pool. After passing over the cooling tubes the water is caused by the screen to fall in a spray to the basin below. As the cooling tubes are mounted at right angles to the direction of the pre-

FIG. 1—THE EVAPORATION SYSTEM installed by Riverside, Calif., to cool hot well water for the city's water supply system works well, judging by the pleased look on the faces of the city commissioners.



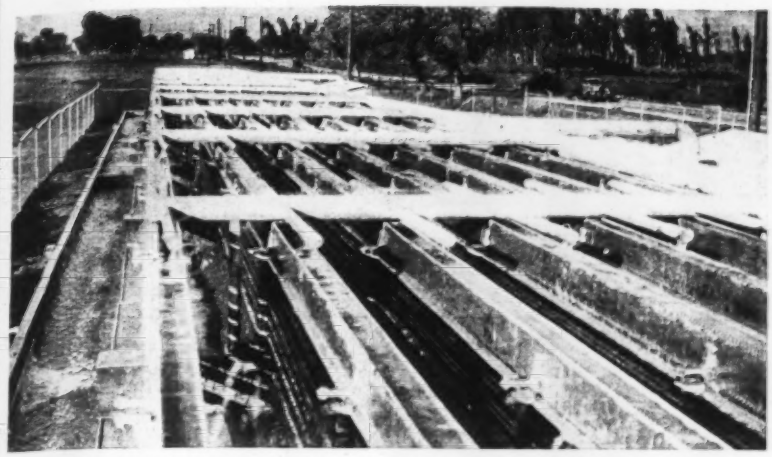


FIG. 2—**COOLING WATER** is fed from cross headers to longitudinal V-shaped troughs from which it trickles down over the pipes containing the hot water.

vailing wind, there is a considerable loss of temperature in the water spray during the fall into the basin.

With the system in full operation the water in the concrete basin remains at about 83 deg. F. It drips off the galvanized tubes at about 88 deg., thus having picked up about 5 deg. in the circuit. The most effective part of the cooling operation is believed to be the evaporation that occurs on the surface of the tubes. The result of the plant operation is a decrease of about 25 deg. in temperature of the well water, that is, water from the well enters the cooling system at 110 degs F. and leaves it to go into city mains at 85 deg. F.

The efficiency of the cooling system varies with the weather. It works best on hot, dry days when evaporation occurs most rapidly. Addition of the screen, a feature provided after operation began, has increased the effectiveness. The amount of water drawn from the hot well to replace what is lost by evaporation is relatively so small that its temperature is unimportant.

The cooling equipment was designed by the Gay Engineering Corp. of Los Angeles and installed under the direction of Robert L. Boulden, superintendent, Riverside Municipal Light & Water Departments, from whom the foregoing information was obtained.

Marsh Buggy Crosses the Swamps

TRANSPORTATION through the Louisiana swamps is ordinarily possible only in shallow draft boats or on foot. To carry geophysical crews and equipment through these swamps, the Gulf Oil Corp. has developed a vehicle, the marsh buggy, which combines the properties of automobile, tractor, and boat. Over smooth ground, this vehicle will travel at a speed of 35 m.p.h. and it can navigate the swamps at ten to twelve m.p.h. In water, floating on its huge balloon tires, it will make a speed of slightly better than six knots. These tires, with a pressure of only six lb. per sq.in., act as cushions over rough ground and prevent jolting of the crew or equipment. A small platform at the rear, higher than the operator's head, is used on location as a stand for surveying instruments. At times, while traveling through the marshes, one of the passengers stands on the platform to direct the driver when his vision is obstructed.

The main frame of the vehicle is an ordinary automobile chassis to which aluminum alloy extensions have been added to give an overall length of 22½ ft. The drum shaped wheels are also of aluminum and are large enough to keep the machine afloat even without the tires. The total weight is 7,500 lb.

The marsh buggy is powered by an automobile engine equipped with an oversized cooling system. At the rear of the motor is a regular passenger car transmission coupled in series with a tractor gear box. The combination of the two transmissions permits ten forward and six reverse speeds. The front wheels receive their power from chains that pass over sprockets on the back axle. This gives a differential action between the wheels on either side but not between the front and rear. The tractor transmission is provided with two brakes, one to control the wheels on the right, the other to act on those on the left. The forward axle is of conventional design with a steering mechanism similar to that of a motor car. The axle is so pivoted in the center that either front wheel can rise two ft. above its mate without distortion.

The tires of the marsh buggy are ten ft. high by three ft. wide and are mounted on 66 in. rims. The tires are so large that the vehicle floats with an immersion of less than 2 ft. If one of the tires becomes punctured, a pressure can be maintained by starting a compressor which feeds air into the tube while the vehicle is in motion. The compressor's output is sufficient to keep the balloon fully inflated until the marsh buggy can be returned to the base of operations.

In water or in the marshes traction is obtained by attaching twelve treads to each wheel. These are made from two in. rubber hose sealed at the ends and provided with an air valve through which they are inflated to a pressure of 25 lb. per sq. in. Since the marsh buggy frequently operates on inland waterways, it carries a marine license and is equipped with all requirements for Class 1 power boats.

THE MARSH BUGGY, auto, tractor, and boat at once, navigates the Louisiana swamps.

Wasteful Thickness Charged To Flat Slabs Without Drop Panels

Service records of slabs one-third thinner than A. C. I. code requires indicate no signs of distress from excessive deflections

By Walter H. Wheeler
Consulting Engineer, Minneapolis, Minn.

BOTH old and new test data show that the rule of thumb thickness formula of the American Concrete Institute, namely $t=.038\left(1-1.44\frac{c}{L}\right) L\sqrt{w'}+1\frac{1}{2}$ results in slabs that are fully 25 per cent thicker than required for conservative design. When $c = 0.2\ L$ this formula reduces to $0.027\ L\sqrt{w'}+1\frac{1}{2}$. The formula recommended by the special committee of the Am. Soc. C. E. in its 1917 report was $0.024\ L\sqrt{w'}+1\frac{1}{2}$ when $c=0.2L$ or more. The factor 0.024 L in this formula is equivalent to 0.0338 in the A.C.I. formula. Just how or why 0.0338 became 0.038 is not clear from the published proceedings. It seems to have just grown that way.

The A.S.C.E. committee, in introducing its formula, said: "In the design of a slab, the resistance to bending and shearing forces will largely govern the thickness, and in the case of large panels with light loads the resistance to deflection may be the controlling factor." We have departed from that sound reasoning and have adopted a rule of thumb which says forget the stresses and deflections and make the slab according to this formula.

There was possibly some ground for conservatism 20 years ago. Engineers were worried about the effect of flow of the concrete. They did not know what might be the result in buildings constructed with thin solid slab floors supported on columns without the aid of beams or girders. This matter was of particular importance in connection with light loads and long spans. There is no longer any good reason for stick-

COMPARISON OF ACTUAL FLAT SLAB DESIGNS WITH CODE REQUIREMENTS

		As Designed and Built										Required by A. C. I. Code				
Kind of Building	Age yr.	Ground Size No. of Stories	Wall Panels	Interior Panels	Column Cap. Diam.	Design Load Lb. Sq. Ft.	Thickness Rough Slab	Col. Strip Steel		Mid. Strip Steel		Thickness Rough Slab	Col. Strip Steel		Mid. Strip Steel	
								Neg.	Post.	Neg.	Post.		Neg.	Post	Neg.	Post.
								sq. in.	sq. in.	sq.in.	sq. in.		sq. in.	sq. in.	sq.in.	sq.in.
1 Hospital	19	227 x 155 3 wings. 4 sty. & base.	17'-0" x 15'-0"	17'-0" x 11'-0"	2'-6"	80	6"	3.35	1.45	0.54	0.54	8"	4.0	1.82	1.33	1.33
2 Garage (1)	10	140 x 100 2 sty. & base.	21'-0" x 20'-2"	22'-0" x 20'-2"	4'-2"	150	8½"	7.28	3.63	1.43	1.43	11¼"	8.0	3.26	2.68	2.68
3 Store & office	19	139 x 112 3 sty. & base.	17'-0" x 16'-0"	17'-0" x 15'-10"	2'-10"	140	6½"	4.2	1.87	.66	.66	8½"	4.7	2.16	1.56	1.56
		Office	floors			100	6"	3.92	1.65	.66	.66	8½"	4.26	1.95	1.41	1.41
4 Office	10	125 x 49 12 sty. & base.	17'-0" x 16'-0"	17'-0" x 16'-0"	2'-4"	100	6½"	4.14	1.98	.69	.69	8½"	4.2	1.9	1.38	1.38
5 General warehouse (2)	18	125 x 75 6 sty. & base.	15'-2½" x 14'-10"	15'-2½" x 14'-10"	4'-6"	350	7½"	3.98	2.31	.88	.88	8½"	5.0	2.3	1.7	1.7
		3rd & 4th flr.			4'-2"	300	7"	3.87	2.2	.77	.77	8½"	4.85	2.2	1.63	1.63
		5th & 6th flr.			3'-10"	200	6½"	3.46	1.61	.54	.54	7½"	3.92	1.86	1.36	1.36
6 Store & office	14	141 x 102 3 sty. & base.	15'-0" x 14'-6"	15'-0" x 14'-0"	2'-8"	145	6"	2.73	1.54	.55	.55	7½"	3.4	1.53	1.12	1.12
					2'-6"	100	6"	2.04	1.2	.45	.45	7½"	2.74	1.25	0.91	0.91
7 Bank & office	11	125 x 87 10 sty. & base.	17'-5" x 16'-10"	17'-5" x 16'-10"	2'-6"	100	6½"	5.08	2.2	.81	.81	9½"	4.1	1.88	1.37	1.37
8 Store & office (3)	8	118 x 63 2 sty. & base.	21'-0" x 19'-0"	23'-0" x 19'-0"	4'-0"	100	8½"	5.78	3.03	1.21	1.21	11¼"	6.5	3.05	2.23	2.23
9 Store & office (3)	8	88 x 69 2 sty. & base.	17'-0" x 19'-0"	17'-0" x 17'-0"	3'-2"	100	7"	4.02	2.53	1.1	1.1	8"	3.9	1.81	1.31	1.31
10 Bank & office (4)	27	125 x 125 10 sty. & base.	20'-0" x 15'-0"	22'-0" x 15'-0"	3'-0"	100	7"	5.11	2.80	0.0	1.65	11"	6.85	2.5	1.3	2.5
	16		26'-0" x 15'-8"	23'-3" x 15'-8"	3'-2"	100	9½"	7.58	3.52	1.32	1.32	12"	8.45	4.95	3.56	3.56
11 High school	15	165 x 75'-0" 2 sty.	24'-0" x 24'-0"	24'-0" x 19'-0"	3'-8"	100	8½"	5.02	2.59	1.65	1.65	11¼"	7.5	3.5	2.52	2.52
12 Hotel (5)	15	139 x 50'-0" 4 sty. & base.	19'-0" x 15'-6"		2'-8"	80	6¼"	3.4	1.54	.9	.9	9"	3.7	1.72	1.27	1.27
13 University (6)	22	129 x 55'-0" 3 stys.	21'-6" x 14'-9"	11'-4" x 14'-9"	3'-0"	85	7½"	4.09	2.75	.99	.99	10½"	5.4	3.15	2.28	2.28
14 Office (7)	21	145 x 50 5 sty. & base.	22'-0" x 16'-0"	4 way slab.	1'-10"	95	7½"	6.62	1.65	0.0	1.43	11¼"	6.25	3.0	1.2	3.0
			16'-0" Sp.		1'-10"			4.75	1.21	0.0	1.43	11¼"	4.55	1.75	.91	1.75
15 Bank & office	23	100 x 140 4 sty. & base.	18'-0" x 13'-9½"	18'-0" x 13'-9½"	1'-10"	100	6½"	3.27	1.16	0.0	1.00	9½"	4.25	1.62	.81	1.62
			13'-9½" Sp.		1'-10"		6½"	2.76	0.85	0.0	1.00	9½"	3.1	1.2	.6	1.2

(1) The first floor of this building has been loaded over several panels with sugar 10 sacks high.
(2) For several years the lower 3 floors of this building carried 400 lb. per sq. ft. of sugar.
(3) This building went thru Helena earthquake, Oct. 1935 without structural damage.
(4) The upper floors of building are 2 bays wide. Wall span is 20 ft. First floor tested when built with fire, load and water test. 1 panel loaded 33 tons.
(5) Upper part of building 2 bays wide 19' span to wall. Above figures for wall span.
(6) Long span is to wall. Above figures are for wall span.
(7) Upper part of building 2 bays wide, 16' span to wall.

ing to this out of date formula. There are plenty of flat slab buildings in the country which are old enough to show beyond any question that the flow, if any, is unimportant, and that its affect has no practical significance in building construction.

During the past year the writer has made a careful survey of some flat slab buildings ranging in age from 8 to 27 years. These buildings are located in various western cities. In all cases the concrete mix was intended to produce 2,000 lb. concrete at 28 days. Test cylinders indicated that that strength was reached in most cases. Most of these buildings are designed for light loads and are partitioned throughout except in the first floor and the basement. Inspection of these buildings showed that no noticeable deflections had occurred in the slabs; that there was remarkably little cracking in tile, terrazza and cement floor finishes; that there was practically no cracking of partitions, and none that could be traced to deflections in the floors. In all cases the buildings are in excellent condition. Some of these buildings have been overloaded for long periods of time. Two of the newest, numbers 8 and 9 in the tabulation, are located in the center of the business district of Helena, Montana, and went through the October, 1935, earthquake without structural damage, as did fourteen other flat slab buildings in the city designed by the writer during the past 25 years of practice.

The tabulation shows the slab thickness and the area of slab reinforcement in the long direction of the panels as built; also the slab thickness required by the A.C.I. formula, and the area of reinforcement required by the A.C.I. code for the slab thickness as built.

It will be noted that the average slab thickness required by the A.C.I. formula is about 35 per cent greater than the average slab thickness used in constructing the floors tabulated. It will also be noted that the area of reinforcement used was considerably less than required by the A.C.I. code.

Civil Engineers Meet in New York

River problems, basic highway planning, sewage, water supply, zoning and power development matters occupy annual convention of American Society of Civil Engineers

WELL ATTENDED as usual, the annual meeting of the American Society of Civil Engineers held in New York Jan. 20-23, was not outstanding in its technical program. A particularly notable circumstance was the award of the John Fritz Medal to Arthur N. Talbot of the University of Illinois. Honorary memberships were conferred on Alex Dow, Detroit; G. H. Duggan, Montreal; Robert Hoffman, Cleveland; J. B. Lippincott, Los Angeles and J. A. L. Waddell, New York. The medal and prize awards are presented in the news pages of this issue. Louis C. Hill, consulting engineer of Los Angeles, was elected president. Inspection trips covered the bridge and parkway improvements and the federal housing work in the metropolitan area.

Chief among the water matters discussed was the stream-development studies that the National Resources Committee carried out during the year —the Drainage Basin Study—under direction of Frederick H. Fowler, of San Francisco. Other hydraulic subjects, included in two sessions of the sanitary division, were tunnel surge phenomena and a committee report on water supply engineering. Road transport and planning matters embraced discussions of parkway effects on traffic, state-wide road surveys, accident factors in road layout, and the relation of rural zoning to highway improvement.

Basic highway data

THREE papers on what might be termed basic highway data—planning, traffic studies and financing—composed the program of the highway division. On the subject of general planning, H. A. Fairbank, U. S. Bureau of Public Roads, outlined the statewide highway surveys now current in 40 states as a joint operation of the bureau and the state highway departments. This pioneer endeavor is planned to provide the first comprehensive inventory of present road facilities on 300,000 miles of state highways and 2,700,000 miles of local roads; to determine the flow of traffic, its kind, origin and destination, and to collect all accident data; and third to study the financing and taxing problem. All three sets of facts, taken together, are counted upon to provide a sound basis for a highway program that will be economically sensible and provide a safe and satisfactory road system. In discussion W. E. Rosengarten, Ardmore, Pa., urged that the needs of the local rural user of the roads should not be too far subordinated to those of through traffic. He mentioned such future needs as space for utilities and sidewalks and provision for moving machinery between farms and fields. G. C. Wright, Rochester, pointed out how Monroe County, N. Y., has been carrying on a similar survey of its own for five years, plotting all existing conditions on 2,000 ft. to the inch maps, so that it is now in a position to plan intelligently for the future; the survey having been made by county officials assures a local viewpoint.

Significant statistics were cited on traffic accidents and their relation to major highway improvements by A. H. Vey, traffic engineer of the New Jersey department of motor vehicles. For example, there were more fatalities per million vehicle miles in a year on 4-lane roads (3.61 deaths) than on either two or three lane roads, for which the figures were 2.75 and 3.53. The greater freedom of movement possible on the four lane road accounts for its greater hazard in Mr. Vey's opinion. He also cited the improvement that has followed installation of dividing strips. Converting a four lane road into two-lane roads by sliding the two halves apart reduced accidents 36 per cent on a 2.1 mile section in a period of five months. While the shortness of the period makes the figure inconclusive, it is nevertheless indicative of important improvement. Comparing accidents at a clover-leaf grade separation and at a signal-controlled intersection nearby, it was shown that in 1934 the respective figures were 6 and 15. A similar comparison between a traffic circle and a signal controlled intersection showed 2 and 26 accidents, respectively. Mr. Vey declared that if the money were available to rebuild New Jersey roads with all of the best safety devices now known to engineers that accidents could be reduced to 25 per cent of present figures. Lacking the necessary funds much nevertheless can be done to increase the engineer's contribution to safer highways. During the discussion which followed, Mr. Vey cited the need for expert accident investigating squads so that the present unsatisfactory method of determining the cause from motorists' statements could be eliminated. Better statistics on accident causes are necessary to plan intelligently for safe road expenditures.

The Henry Hudson Parkway in New York City furnished the example of

financing that completed the highway program. In discussing the importance of this new artery in its relation to Westchester County parkway traffic, Jay Downer, consulting engineer, New York, revealed that present indications, based on five weeks' operation of the Henry Hudson Parkway, are for an average in 1937 of 12,360 vehicles per day. This compares with the estimate of 9,700 vehicles per day made for the benefit of the private bankers who floated the loan of $3,100,000 for the construction of the parkway. The unusual conservatism of traffic forecasting was necessary in order to secure the loan. The bankers agreed to loan a further $1,400,000 for constructing an upper deck on the bridge across the Harlem River when traffic warranted. There are indications that this added facility may be needed many years before the time the bankers apparently thought that it would. Mr. Downer expressed interest in the future competitive situation between this new 10 cent toll parkway which offers speed and convenience and a nearby free bridge and main highway route offering a slightly shorter route but one that is badly congested.

Structural division

THE feature of the structural division meeting was a brief paper by C. F. Goodrich, chief engineer, American Bridge Co., covering the building of the San Francisco-Oakland bridge, followed by a sound film prepared by the U. S. Steel Corp. covering details of the superstructure erection, the first such recording of a complete construction job. In the other paper presented, E. L. Durkee, assistant engineer, Bethlehem Steel Co. and T. J. Barnett, chief engineer, United Fruit Co., covered the design and construction of a steel pier at Puerto Armuelles, Panama. The pier extends for 1530 ft. into the ocean to reach a 53 ft. water depth necessary for ships that dock at this port to take on banana cargoes.

The pier is particularly notable for its use of steel H-piles up to 120 ft. in length, the longest sections yet rolled. These piles were encased before driving with 2 in. of air applied concrete from a point 10 ft. below mud line to the elevation of low water. Because of the heavy loads per pile, up to some 50 tons, the lower portions were also filled out by timbers providing in the maximum case a bearing area 12x27 in. The piles were driven satisfactorily by a single-acting hammer, and the encasement was not damaged even under such punishment as 42 blows for the last inch of penetration.

The pier itself was designed to resist a 10 per cent earthquake load, and the outer portion in deep water was built as a unit without expansion joints. The pier carries three railroad tracks and at the outer end a pier shed. The longitudinal bracing between the pile bents below the deck is designed as a continuous truss. No bracing is used below the low water line. The papers on the steel pier took so much time that presentation of a scheduled paper by Harold E. Wessman (University of Iowa) and Shortridge Hardesty had to be cancelled.

Water treatment developments

THE sanitary engineering division held two technical sessions—one devoted to water supply and the other to sewage treatment—and in addition, sponsored a joint dinner meeting with the New York State Sewage Works Association at which George B. Gascoigne, consulting engineer, described features of the sewage disposal program at Cleveland. Officers elected for 1937 were H. E. Miller, chairman and Earle L. Waterman, secretary.

A resume of the basic principles to be observed in water softening plant design was given by W. H. Knox, assistant engineer, Ohio health department. Such facilities are rapidly being added to municipal supply systems in Ohio; there are now 79 such installations (about ⅓ the total number in the U.S.) either in operation or under construction in this state, and almost every type of softening process is represented. In every case the economic advantages of softening far outweigh the slight cost it entails.

Basing his observations on long experience with softening plants, Mr. Knox called attention to the following developments in practice: the desirability of quick or flash-mix facilities to assure uniformity of chemical admixture; the use of dry-feed machines in lieu of solution-type devices; the economy of pneumatic equipment for handling chemicals; abandonment of baffle mixers in favor of patented mechanical devices; and the increasing use of continuous sludge removal equipment in clarifiers.

Zeolite softening installations for municipal plants are comparatively new in Ohio, the first one having been made in 1927. Their advantages were listed as: (1) no sludge produced; (2) low first cost; and (3) simplicity of operation making expert supervision unnecessary. Against these the following disadvantages were noted: (1) They do not perform any bacterial removal; (2) manganese and iron must be removed prior to softening and (3) they offer no aid in pH correction.

In discussion it was stated that the greatest drawback to the lime-soda softening method was the problem of sludge disposal. Lime recovery was mentioned as a possible solution. Further attention may be focussed on the lime-soda process since it has been found that it is effective in removing a certain amount of fluoride from water; fluorides are causing tooth [illegible] troubles in about 28 states.

Measuring surge in tunnels

STUDIES of surge in water and sewer tunnels which led to the development of a method of model analysis were described in a paper by A. B. Morrill and Harry K[illegible]gren, associate civil engineers, department of public works, Detroit. Their problem was to obtain a measure of the distribution and amount of kinetic energy in a 12-mi. sewer tunnel of varying diameter produced by surge waves which might occur from the stoppage of pumps. By reducing the sewer of many diameters to an equivalent sewer of one diameter, and then building a scale model of a 50 ft. length of copper pipe, it was possible to measure surge effects and design a relief overflow chamber to handle the volume and rate of spill at the pumping station.

The final paper in the water supply symposium was a review of progress in 1936 by Thomas H. Wiggin, consulting engineer, New York City.

Sewage treatment economics

STRESSING the fact that the design of a sewage treatment plant is a complex problem in economics, and that purification requirements are modified by many considerations peculiar to each local situation, George J. Schroepfer, assistant chief engineer, Minneapolis-St. Paul Sanitary District, outlined factors that influence the selection of treatment processes. His conclusions were based on comprehensive analyses of cost and operating data from plants constructed within the last decade.

In general it was indicated that the greater the degree of treatment desired, the higher the cost per unit of purification.

The most important factor influencing plant design was stated to be the character and condition of the stream into which the effluent is discharged. Only after careful evaluation has been made of the pollution load that a stream can carry without nuisance is it possible to determine the necessary degree of treatment. Where river conditions vary widely with the season of the year a combination of primary and secondary treatment devices is in order. Over-treatment is economic waste.

Comparisons of the cost and efficiency of various processes under different operating conditions were shown by means of curves and tables. These revealed a number of interesting facts. For instance, when construction costs of sedimentation plants are related to detention time and per cent purification accomplished, it is evident that where economical removal of suspended solids is desired the settling tank should not provide more than 1½-hr. detention; in the case of B.O.D. removal a detention

time greater than 3½ hr. is uneconomical.

Stream pollution analyses

A TECHNIQUE for stream analysis to aid in determining how much sewage treatment should be provided for a given locality was presented in a paper by Clarence J. Velz, acting chief engineer, PWA, New Jersey office, Newark, N. J. Natural agencies of deoxygenation and reoxygenation are simultaneously effective in all bodies of water—the first may be considered a liability and the second an asset. Deoxygenation is a complex biochemical process influenced by time, temperature and nature of pollutional waste. Reoxygenation, also a complex phenomenon, is a chemical process influenced primarily by concentration of dissolved oxygen, time, temperature, water depth and turnover. An equation, integrating these factors into a single expression for resultant oxygen, has been developed by Phelps and Streeter. Owing to its complexity, however, it is subject to misunderstanding and misapplication, according to Mr. Velz, who presented graphical means of solution for easy and rapid application of the fundamental principles that have been established mathematically.

Reoxygenation and deoxygenation were treated separately. For the former a chart was presented to show that oxygen absorption under any set of conditions (in tidal waters as well as others) can be obtained accurately without painstaking mathematical work. Another chart represented graphically the time-temperature functions concerned with stream deoxygenation. The curves (called Standard Demand Curves) on the chart signify that at a given temperature in successive intervals of time, the proportion of the oxygen demand satisfied is always a constant percentage of that remaining at the end of the previous interval. With the logarithmic slopes of standard demand curves, and with the distance between stream stations expressed in time of passage, the temperature of the water and the quantities of pollution contributed at each station, it is a simple graphical operation to integrate the resultant demand and determine the relative responsibility of pollutors at any location on the stream. Mr. Velz also outlined a graphical procedure for evaluating population increase by means of a logistic growth scale.

Sewer maintenance

AN effective program of sewer maintenance procedure, developed after first making a study of conditions and standards in a number of cities in California, was described by Raymond R. Ribal, office engineer, Oakland, Calif. His findings disclose many irregularities and departures from standard practice in sewer construction, all of which influence maintenance cost because eventually they must be corrected.

Improper design of laterals and main sewers to care for ultimate needs has made it necessary in various places to construct duplicate facilities. Minimum size regulations for laterals have frequently been ignored by contractors and subdividers where inspection by the city was lax; the Oakland survey, for instance, reveals that there were more than 100 miles of 6 in. laterals installed despite the regulations forbidding anything less than 8 in. Flat grades are a source of much trouble, and although flush tanks can be installed they are expensive to operate and service.

One of the principal items calling for maintenance attention is manholes. Here again, subdividers have been at fault by failing to place them at specified distances or where a change of alignment occurs. To remedy the nuisance of noisy manhole covers it is recommended that heavier castings be adopted or that they be machined to a close fit. Cracked sewer joints are a major item in a maintenance program because they permit infiltration of ground-water and the entrance of tree roots. A sulphur joint compound recently tried to insure tight joints was discovered to be subject to attack by certain bacteria in warm climates causing disintegration.

Mr. Ribal recommended that stringent inspection be provided whenever new sewers or house connections are made and that an inspector be stationed wherever utility companies are working underground. Organization and supervision of field crews with definite assignments of work each day, and careful record-keeping of all operations are pre-requisites to economical maintenance.

Rural and urban zoning

IN THE city planning section a paper by Laurance J. Carmalt, consulting engineer, New Haven, Conn., formed the basis for discussion of rural zoning as an adjunct to state highway improvement. Proper design of rural highways should include control not only of the roadway itself but of the borders of the highway, and the adjacent country. Control of the countryside, although much easier in rural than in urban districts, is seldom considered in rural highway planning. Rural zoning based upon master plans prepared by a large governmental unit, such as a state board, is more effective than with small units where personal relationships are apt to influence zoning decisions.

In the discussion following Mr. Carmalt's paper, J. J. Darcy, New York State department of public works, explained that as yet too few funds have been made available for rural zoning although a major problem in the design of any highway should be the coordination of the use of the highway and the land along its borders. Russell V. Black, planning consultant of New Hope, Pa., urged the construction of a highway only after sufficient right-of-way has been purchased and contracts made with the landowners defining specific uses for the adjoining land. Various types of legislation for rural zoning were explained by Eugene H. Callison of the New York state planning board.

Discussion of urban zoning was based upon a paper by Hugh E. Young, chief engineer, Chicago Plan Commission, describing the work of rezoning Chicago. Out of 51 sq. mi. in the center of Chicago, 44 are considered "blighted" because of the failure to rezone soon enough. Retardation of development in the blighted area is considered due to the failure to rezone with changing conditions rather than to improper initial zoning. As part of work in rezoning Chicago, questionaires were sent to officials of 154 cities, and replies received from 102 cities indicated that 88 were zoned, that rezoning was considered necessary in 59, that 39 were partially rezoned, and that 9 were completely rezoned.

In discussing rezoning, Robert D. Kohn, architect, New York City, urged education of the general public as to difference between the sale price and actual value of city land as the first major step. Rezoning has aided in the collection of taxes in Cincinnati, Ohio, according to Myron D. Downs of the planning commission of that city. Arthur L. Vedeler, secretary of the city planning board, Rochester, N. Y., stressed the need of strict enforcement of zoning free of political or other favors.

Power

THE power division devoted itself to a review of its accomplishments in the 14 years of its history and considered its program for the future. Looking backward, Lynne J. Bevan, chairman of the division from 1929 to 1934, presented a paper outlining the division's work, listing its papers and summarizing its special studies. The three principal studies undertaken by the division have been completed, namely, its studies of ice problems at hydro-electric plants, its compilation of data relating to the silting of reservoirs, and its draft of a model law for state control over dams.

Ford Kurtz, secretary of the division's executive committee, presented a paper outlining his personal views as to what the division should undertake in the future. Mr. Kurtz would have the division devote major attention to papers relating to design and construction of small power plants as he believes that this is the field in which private capital and the private consulting engineer will be most active in the next few years. He favors putting papers relating to

power plants of moderate size in second place and would give scant attention to descriptions of the large federal power undertakings which are adequately covered elsewhere.

As to special committee work, Mr. Kurtz favors setting up one or more of the following: (1) A power-cost committee to accumulate data on both hydro-electric and steam power plants, to set up its own system of allocating costs and to correlate and publish its data currently; (2) A committee on power plant depreciation and obsolescence; (3) A committee to report annually on progress in power plant design; (4) A committee to report annually on progress in prime mover design; (5) A committee on the valuation of power plants; (6) A committee to assemble data on the several public power authorities, on how they allocate costs, etc. In concluding his report, Mr. Kurtz raised the question as to whether the division should confine itself strictly to technical matters or whether it should discuss the broader economic questions, some of which are matters of a controversial nature.

William P. Creager, commenting on Mr. Kurtz' suggestions, stated that he believed the division should limit its papers to the civil engineering features of power development, but should make its compilation of data wide enough to cover the economic questions. He especially endorsed the committee on power costs on the basis that it would be able to produce data to show the correct place of hydro-electric power in the nation's economy.

L. F. Harza stated that in planning the future course of the division the executive committee should decide whether the division should serve only the society's members or whether it should endeavor to guide public opinion in the proper use of technical facts. He believes that the division could well serve as a clearing house for the many small but valuable items of information relating to power cost that the members develop in their daily work.

The chairman of the hydraulic division of the American Society of Mechanical Engineers, stated that the representation of the civil engineers on that division's committee on water hammer had been restored, representation having been allowed to lapse inadvertently. He stated that the committee planned to take up the subject of penstock failures and hoped to have a report ready for the December meeting.

Daniel W. Mead, retiring president of the Society, expressed himself forcefully on the question of whether or not the division should take up the discussion of economic questions. He is strongly in favor of having engineers express their views on subjects on which they have better information than is available to the general public.

At the close of the meeting a motion was passed recommending that the executive committee consider initiating Mr. Kurtz' first, second and fifth recommendations.

River basin studies

THE reasons for undertaking the past year's hurried survey of river basin and development possibilities, and how it was carried on, were outlined by Abel Wolman and Frederick H. Fowler, in somewhat general terms, in papers before the society's general session. Mr. Wolman as head of the Water Resources subcommittee had the main responsibility of planning the survey, while Mr. Fowler directed it in detail. Their summary of the work was prevented from dealing with the findings in specific terms, however, because the report is still in the President's hands.

Intended first of all to show what river improvement projects ought to be undertaken at once—possibly as federal projects—the river basin survey was guided by the principle of developing the maximum use of river water, so far as such use might be found economically and socially desirable. For the purposes of the survey, Mr. Wolman said, the country was divided into 14 regions, comprising 127 separate stream basins. Each region was assigned to one man, whose work was to coordinate local information and effort, relying on the state planning boards.

Many basic deficiencies limited the work: lack of adequate hydrologic data, incompleteness of topographic mapping (over half the country is still unmapped as to topography), deficient knowledge of coastal and soil erosion, and lack of information on regional power markets. However, information on some 7000 river projects was brought together in the survey.

As to priority, the projects were graded under three heads: (1) ready for construction, (2) deferred, because not ready to go, and (3) indeterminate. As to what Mr. Wolman called "debatable" projects, apparently meaning such as the Florida Canal and Quoddy, he indicated that the committee did not attempt to weigh their merits if they had already been started.

A sufficient number of projects was recommended to cover from six to ten years of work if carried on at the rate of past river improvement expenditure. The selection was made without regard to where the funds would come from.

As Mr. Fowler emphasized, the 1936 survey—begun in March and completed in report form by December—is only an initial or reconnaissance survey, which should be followed by further studies. Such additional investigation, he said, will require an adequate staff of high caliber and an ample budget. In the present reconnaissance the rating of projects for priority presented special difficulty. Generally the rating appears to have been based on present conditions rather than those of the future.

Two specific basin studies, Red River of the North and Upper Rio Grande, were separately discussed by A. W. Horner, consulting engineer, St. Louis, and Prof. H. H. Barrows, University of Chicago. The situation on the Red was shown to be particularly serious, as the river once carried steamboats as far as Fargo but now is often dry. Rainfall has decreased from a mean of 23 in. to 20 in. in 30 years; nevertheless severe floods must be reckoned with, although the last great flood occurred 20 years ago. Numerous small communities depend on the river, and throughout the basin the curve of diminishing water supply has already met the curve of increasing demand, Mr. Horner said. The basin has a population of nearly half a million, whose existence in large part depends on the river system. Marsh storage (destroyed by past drainage operations) is the chief dependence for equalizing the river flow. A tentative series of storage projects has been drafted, by cooperation of the authorities of the three states concerned.

On the Upper Rio Grande (above Fort Quitman) there are demands for more water both in New Mexico and in Colorado. Study of supply, consumption and prospective additional uses is in progress for the National Resources Committee at the request of the Interstate Compact Commission of the states concerned. Subjects included are consumptive use of water, requirements of irrigable lands, storage possibilities, and possible transmountain diversions from Colorado River tributaries. Various federal bureaus are cooperating.

Following these discussions, Dean Thorndike Saville, New York University, summarized the recommendations for extension of federal and state activity in obtaining basic hydrologic data recently reported by a subcommittee. Without better data than we now have on precipitation, streamflow, evaporation, etc., he said, efficient planning for stream utilization is not possible. There is at present no satisfactory criterion for placing one use ahead of another, and many conflicts develop.

On the latter point, L. K. Sherman, of Chicago, who carried out the drainage basin study for the Great Lakes basin, brought out a specific difference of opinion. The views of the Great Lakes states as to priority of water use were that stream pollution removal comes first, flood control second, and navigation third, whereas in his opinion Great Lakes navigation is most important.

Stream regulation projects have not been studied in detail, Mr. Sherman added, and the state authorities complain of this deficiency in the stream-basin study. He believes that the next step of the Water Resources Committee work should be study of stream regulation; and he also believes that this study is essentially a federal rather than a local responsibility.

Planning and Stabilization Topics at Colorado Highway Meeting

THE FOLLOWING REPORT of the Eleventh Annual Highway Engineering conference held by the University of Colorado at Boulder was prepared by Prof. C. E. Eckel, head of the Civil Engineering Department of the University, especially for Engineering News-Record at our request. —EDITOR

HIGHWAY planning and subgrade stabilization were principal topics of discussion at the Eleventh Annual Highway Engineering Confernce held at the University of Colorado, Boulder, Jan. 14-15. Besides these two subjects, the program included papers on safety, fill compaction, concrete pavements and grade separations. The conference is sponsored by the Civil Engineering and Extension Departments of the University, and has been actively supported by the Denver district of the U. S. Bureau of Public Roads and the state highway department. Representatives of highway departments of nearby states also participated in the meeting.

H. E. Cunningham, U. S. Bureau of Public Roads, San Francisco, presented a paper written by H. S. Fairbank, chief, division of information of the bureau on "Objects of the Statewide Highway Planning Surveys". Cooperating with the Bureau of Public Roads in this project are forty state highway departments. The pioneering stage of our highway development has been passed and with first needs of traffic satisfied, it is necessary and profitable to take stock of what has been done, and to determine the character and extent of economically justifiable further development. The surveys consist of three principal parts: An inventory of existing roads and their condition; traffic studies; and financial studies to estimate the maximum highway development that can be sustained. The limit of highway development will come not when we have built all the roads we can pay for, but when we have built all that we are willing to indefinitely pay to maintain. The necessity of perpetual maintenance was emphasized and also the need of a coordinated system of highways based on relative importance and usefulness rather than the present arbitrary classification. J. E. Wiley and John E. Furlong, managers, respectively, of the Wyoming and Colorado state-wide planning surveys described the organization and methods which are used in their states to carry on the survey.

Railway grade crossing elimination programs of New Mexico, Wyoming and Colorado under the public works allotment of 1935 were described by J. W. Courter, assistant bridge engineer, U. S. Bureau of Public Roads. In these states 54 grade crossings involving 163 tracks will be eliminated either by underpasses or overpasses or by relocation of the highway.

"Trends in the Design and Construction of Highway Pavements" were discussed by Prof. H. J. Gilkey, of Iowa State College. Advances are being made in soil stabilization, improved drainage facilities, expansion joints and joint fillers, cross and longitudinal doweling, and more intelligent design of pavements. Prof. Gilkey believes that highway design is approaching stability because human and mechanical limitations seem to indicate a maximum safe driving speed of about 60 mi. per hr. He made a plea for consistent design standards, uniformity of traffic signs and laws, and especially, better coordination between laboratory and field in order to get what we know into the job.

R. F. Blanks and E. M. Vidal, U. S. Bureau of Reclamation, presented a joint paper on placing of concrete in structures with particular reference to vibratory methods. Vibration is a method of compaction and not of spreading concrete. Cement is the least stable ingredient of concrete; with better compaction, a minimum of cement may be used to obtain a desired strength and consequently a better concrete is produced. However, the mix must be properly designed and care taken not to over-vibrate, otherwise vibration will do more harm than good. A dry mix flows readily under vibration while a wet mix segregates badly and is harmed by use of vibratory methods. High frequency vibrating is favored by both speakers.

"Roadside Improvement of Highways" was discussed by Howard W. Baker, National Park Service and M. Walter Pesman, Colorado state highway department. Mr. Baker stressed fundamental principles, such as conservation of natural beauty, need for adequate right of way, balanced quantities in grading operations, suitable types of planting, and maintenance, while Mr. Pesman emphasized erosion control, effect of soil conditions, plantings suitable for Colorado and other western states, vulnerability of plantings to pests, and mortality of planted materials. Mr. Pesman suggested highway zoning to eliminate disagreeable features, for example, auto grave yards, bill boards, and roadside stands.

Engineering, education and enforcement are essential features of successful traffic administration according to Earl J. Reeder, chief traffic engineer, National Safety Council. The approach to the design construction and maintenance of safe highways is through the accident records. Highways, free from hazards, and with proper signs, signals, and markings, education of drivers and pedestrians, and aggressive and impartial law enforcement are imperative if the state is to properly discharge its responsibility for safe transportation.

Establishment of a permissible limit of settlement, determination of the required density of material to be used in the fill if the permissible limit is not to be exceeded, and provision for adequate engineering supervision were advocated by Worth D. Ross, U. S. Bureau of Public Roads, in a paper on "Compaction of Earth Fills and Embankments in Highway Construction".

The general aspects of soil stabilization were discussed by Harold Allen, state highway commission of Kansas. Mr. Allen described the use of Portland cement for stabilization purposes as developed by W. H. Mills of the South Carolina highway department and then described a project on which 5 lb. of cement per sq. yd. per in. of compacted depth was used. Eight inches of loose soil made a 6-in. compacted lift. Equipment used was the tandem disc harrow and spring-tooth alfalfa sod harrow in train, a gang plow, a walking plow to clean along the edges of the lift and a 10-ft. blade. Water was applied to the mixture through $\frac{3}{4}$-in. hose and after mixing and shaping, each lift was rolled with a sheepsfoot roller having a unit bearing pressure of 140 lb. per sq. in. The contract price for this work was 80¢ per sq. yd. While it is premature to draw conclusions, it is believed that cement can be used successfully and economically for this purpose.

Frank S. Gilmore of the Asphalt Institute and C. L. McKesson, and of the American Bitumuls Co., discussed the use of liquid asphalt for soil stabilization purposes. Mr. Gilmore cited results obtained in the sand hill region of Nebraska where it has been found that any desired degree of stabilization can be obtained by mechanical manipulation of liquid asphalts and sandy soils. He also described the Ingalls sub-oiling process which has met with apparent success in Missouri. In the Nebraska work, soil particles are comparatively large and relatively thick films of asphalt mastic act as a binder, while in Missouri small soil particles are waterproofed by a thin film of asphalt. The sub-oiler is pulled by a light truck or tractor and through teeth set to a predetermined depth bituminous material is pumped into the

soil. This asphaltic material disperses upward through the overlying soil, water proofs and thereby stabilizes the soil particles. Almost any material which will develop satisfactory bearing strength when dried can be stabilized with emulsified asphalt.

Soil stabilization in Yellowstone National Park highways has been attained by a proper mixture of soils available locally in the Park, according to Mr. C. F. Capes of the U. S. Bureau of Public Roads. Highway locations through peat bogs or swamps are excavated 5 or 6 ft. and rebuilt with crushed rock to grade elevation. In most instances, the greatest subgrade problem in the park is drainage, and if adequate drainage is provided, soil stabilization is practically accomplished. Subdrainage which permits preservation of the landscape is used extensively. Not lack of appreciation of more scientific methods, but financial necessity has encouraged the use of local materials for soil stabilization in Yellowstone Park.

Book Reviews and Notes

A Monthly Commentary on Current Additions to the Civil Engineer's Library

Little Known Railroading

A PIONEER SOUTHERN RAILROAD—By Thomas D. Clark. 1936. 170 pp. Published by the University of North Carolina Press, Chapel Hill, N. C. Price, $2.

HISTORICAL INCIDENTS of part of the American railroad-building epoch about which little has been published heretofore is presented in a novel and interesting form in this book concerning pioneer efforts leading to the construction of railroad lines between New Orleans and Cairo. The early days of six railroads, now part of the Illinois Central system, are described: the New Orleans & Jackson; Canton & Jackson; New Orleans, Jackson & Great Northern; Mississippi Central; Mississippi Central & Tennessee; and the Mississippi & Tennessee. The book also contains a chapter on the railroads of the lower Mississippi Valley during the Civil War and Reconstruction Period.

Indeterminate structures

STATICALLY INDETERMINATE STRESSES: AN ELEMENTARY TREATISE—By John Ira Parcel and George Alfred Maney. Second Edition. 432 pp. Published by John Wiley & Sons, Inc., New York. Price $5.00.

ADVANCE IN THE ART is responsible for the second edition of the Parcel and Maney text on statically indeterminate stresses, first published in 1926. For example, new material relating to the rigid joint type of structure covers the Hardy Cross method of moment distribution, a generalization of the slope deflection method that makes it applicable to frames containing members with variable cross sections, and the Maney-Goldberg adaptation of the slope deflection method to the analysis of multi-story building frames. A chapter is also added covering the theory of suspension systems on the ground that the last decade has witnessed a remarkable extension of the suspension bridge type for relatively short span structures. As in the first edition, the first third of the book is devoted to the theory of elastic deflection and indeterminate stresses, the middle third to specific treatments of continuous girders, the rigid frame, the elastic arch and secondary stresses, while the latter part of the book is devoted to general discussion and a historical survey.

Roadside Planting

ROADSIDES, THE FRONT YARD OF THE NATION—By J. M. Bennett. 233 pp. Published by The Stratford Co., Boston, Mass. Price $3.

UP TO a few years ago technical road literature was centered on the paved traveled way, even to the neglect of shoulder treatment. The strip of land beyond the ditch, conveniently named the roadside, was even more completely neglected. Practice in the more progressive states, however, has been making a good start on roadside development, and the subject today claims rank as one of the important phases of highway administration and engineering. J. M. Bennett's book "Roadsides" is therefore a welcome addition to the road library. It combines interestingly a discussion of roadside policies and values with practical pointers on the handling of grass, shrubbery, trees and wire lines.

While the subtitle of the book, "The Front Yard of the Nation," might suggest that the book is dominated by an estheticist's viewpoint, the actual treatment of the subject is sane and utilitarian. A cover of vegetation on the banks that border the road is quite as useful as it is pleasing, by protecting the soil from erosion and reducing maintenance costs. The author does not carry this point far enough to prove by figures that on the long pull there is a decided economy in developing a thorough vegetative cover on the road banks, but his argument permits the inference at least that good grass planting will save money. As to trees, the utilitarian purpose is probably much smaller, but the attractiveness of the road well shaded by bordering trees is so generally recognized that economy reasoning is less necessary.

Grass planting and preparatory treatment, as well as the handling of trees, is dealt with in considerable detail, with specification extracts from Wayne County practice. The discussion of wire lines is limited to statements of reasons why trees and wire lines need not conflict with each other, and arguments for rigid control of clearance pruning. Of other roadside features, comfort stations are given some attention.

It may be hoped that this book will prove to be the beginning of a substantial literature of roadside treatment, including thorough discussion of the relation between the roadside and highway safety (including sight distance), parking places and small parks of the kind so skilfully developed by Connecticut, warning and information signs, and also highway lighting. These elements of the roadside, together with effective handling of grass, shrubbery and trees ought to receive a great deal of attention in the next decade or two, and highway engineers are the logical custodians of these subjects, rather than outside specialists.

Miscellaneous Notes on Booklets and Reprints

THE SAN FRANCISCO-OAKLAND BAY BRIDGE is described in detail in a finely illustrated booklet published by the United States Steel Co. through its subsidiary, the American Bridge Co., Frick Building, Pittsburgh, Pa. Price $1.

SALT IN ROAD CONSTRUCTION is the subject of three pamphlets published by the Salt-Soil Road Bureau of the Morton Salt Co., Chicago. They are entitled "Construction Manual for Salt-Stabilized Roads—Base and Wearing Courses", "Recommended Specifications for Salt-Stabilized Roads—Base and Wearing Courses", "Salt-Stabilized Base Courses for Bituminous Surfacing." Copies may be obtained from the company on request.

ENGINEERS IN CHINA have replied to the criticism of the engineering work connected with Chinese irrigation developments that was expressed in the League of Nations' report on "Hydraulics and Road Questions in China"

(*ENR*, July 23, 1936, p. 129). The reply, published in the November-December, 1936, *Journal* of the Association of Chinese and American Engineers, is sharply critical of the League's committee of engineers for condemning the work of other engineers whose knowledge of the peculiar conditions in China was much greater than they could possibly have obtained in their very superficial examination of the irrigation work there. A reprint of the paper by Oliver J. Todd and others is available from the Association, Peiping, China.

ACTIVITIES OF MARINE BORERS in the port of Sydney, Australia, the subject of a report by the Marine Services Board of New South Wales in 1932, are the subject of a further report by the same board, Supplementary Report No. 1, entitled "Destruction of Timber by Marine Organisms in the Port of Sydney."

New Books and Revised Editions

[Those desiring copies of the books listed below or mentioned elsewhere in this section should order them from the publishers or from their local booksellers.]

PLUMBING ENGINEERING—By Walter C. S. Cleverdon. 445 pp. Published by Pitman Publishing Co., New York and Chicago. Price $3.50.

MECHANICAL WORLD YEAR BOOK: 1937—Fiftieth Year of Publication. 360 pp. Published by Emmott and Company, Limited, Manchester, England. Price, 1s. 6d. net.

DAMS—A Bibliography of Books, Periodicals, and Society Publications Appearing From January 1924 Through March 1936. Compiled by Alvan W. Clark. 256 pp. Published by The Engineer School, Fort Belvoir, Va.

INDEX TO PROCEEDINGS: 1918 to 1936—American Society of Municipal Engineers—International Association of Public Works Officials. 70 pp. Published by the American Public Works Association, Chicago.

CONSTRUCTION INDUSTRY VOLUME I—CENSUS OF BUSINESS: 1935—116 pp. Published by United States Department of Commerce, Washington, D. C. Price not stated.

KEMPE'S ENGINEER'S YEAR BOOK: 1937—43rd Annual Issue. 2,676 pp. Published by Morgan Brothers, Limited, London, England. Price, 31s. 6d.

THE MECHANICAL TESTING OF METALS AND ALLOYS—By Field Foster. 266 pp. Published by Sir Isaac Pitman & Sons, Ltd., London, and Pitman Publishing Corp., New York. Price, $3.75.

ELECTRIC POWER DEVELOPMENT IN THE U.S.S.R.—Committee for International Scientific and Technical Conferences. 496 pp. Published by Inra Publishing Society, Moscow, U.S.S.R.

THE BRITISH RAILWAYS—By Alex. Newlands. 135 pp. Published by Longmans, Green and Co., London and New York. Price, $3.

SOURCES OF POLLUTION—Hoosack River, Blackstone River, Nashua River and Housatonic River. Four WPA Reports sponsored by the Massachusetts Department of Public Health and published by the Department of Public Works, State House, Boston, Mass.

Letters to the Editor

Scrapers in Fill Compaction

Sir—In your Jan. 7, issue I have read the article entitled, "Measures of Soil Behavior Are Still Imperfect," by A. Casagrande. This is to my mind an excellent story on soil behavior, and the conditions with which highway engineers are daily confronted.

On page 9, the picture is of one of our scrapers dumping its load upon the fill. This particular scraper as shown in this picture is one of our old bottomless semi-drag scrapers which was built in 1929. The caption brought out the fact that through the use of this type of equipment it was possible to control the depth of spreading thereby building the fills in layers which naturally is instrumental in the securing of proper amount of compaction. But using our present day scraper it is possible to control the depth of spread to any desired thickness. This spreading process is controlled and achieved through the medium of the push-out tailgate.

Due to the fact that we can control this depth of spread and that immediately after our rear tires pass over the newly spread earth some highway departments are not requiring the contractor who is using our equipment, to use the sheep's foot roller as a compaction unit. It is felt that our large tires carrying the weight of the scraper over the evenly-spread load secures a sufficient amount of compaction.

R. G. Le Tourneau, Inc.
Peoria, Ill. H. L. STILLEY,
Jan. 13, 1937

Put Elevations on Benchmarks

Sir—For many years elevations have been left off the bronze plugs set as benchmarks by the U. S. Coast & Geodetic Survey. Instead, only code symbols are used; elevations may be obtained only by writing to Washington. Even though elevations of benchmarks do change and despite the fact that calculations sometimes are not finally completed and corrected when a benchmark is set, it certainly is a disappointment to surveyors to find these benches of no use whatsoever to a field party. As a check on surveys in progress they could be valuable aids.

At a critical time in a recent survey the writer found one of the familiar metal hubs of the U.S.C.&G.S. and on it was the illuminating (?) inscription "M.T.M.1R.E. 1/16th C.S.4C." How much more useful it would have been if we had found an elevation figure!

If the U.S.C.&G.S. must protect itself against changing elevations would it not be sufficient to record on the B.M. the date as well as the elevation? If the fear is that later corrections might change the computed level slightly, could not the elevation to the nearest foot be marked on the hub when it is set? Even an approximate figure often would be of real value to field parties and the absence of any information at all deprives field men of much of the value they otherwise would get from this important branch of the Survey's activities. Incidentally, it brings frequent and vigorous condemnation of the Survey from field men.

Engineers must stand by the results of their work and their computations; the U.S.C.&G.S. should not attempt to escape this responsibility as the present practice makes it appear to do.

K. T. ROBERTS
Yuma, Ariz.,
Dec. 15, 1936.

Volume of Intersecting Arches

Sir—In the very interesting article by L. J. Sack (*ENR* Oct. 8, 1936, page 507), the common volume of two intersecting arches is determined for equal rises and spans. It so happens that in most of the arches which intersect and for which a common volume must be determined, the rises and spans are not equal. The following generalized formulas are true for any two parabolic or circular intersecting arches having unequal rises and spans.

(a) Arches that are segments of parabolic cylinders.

Equation of cylinders are $z = \frac{4r_1}{S_1^2}x^2$

$$y = \frac{4r_2}{S_2^2}x^2$$

If S_1 be the shorter span and r_1 the corresponding rise, then the common volume is

$$V = 2\int_0^{S_1/2}\int_{rm}^{\frac{4r_2}{S_2^2}x^2}\int_{r_2}^{\frac{4r_1}{S_1^2}x^2} dz\,dy\,dx$$

$$= \frac{r_1r_2S_1^3}{5S_2^2} - \frac{r_2^2S_1^3}{3S_2^2} - \frac{r_1^2S_1}{3} + r_1r_2S_1$$

(b) Arches that are segments of circular cylinders.

Equation of cylinders are

$x^2 + z^2 - 2Rz = o$

$x^2 + y^2 - 2Ry = o$

If S be the shorter span and r_1 the corresponding rise; then the common volume is

$$V = 2\int_0^{S_1/2}\int_{r_1}^{R-\sqrt{R^2-X^2}}\int_{r_2}^{R-\sqrt{R^2-X^2}} dz\,dy\,dx$$

$$= R^2S_1 + \frac{r_1r_2S_1}{2} - \frac{r_1^2S_1}{2} + \frac{r_1RS_1}{2} - \frac{r_2RS_1}{2}$$

$$- R^2(2R - r_1 - r_2)\sin^{-1}\frac{S_1}{2R} - \frac{S_1^3}{12}$$

The arches used in New York City subway construction are segments of circular cylinders with R = 5 ft.

JOSEPH SELIGMAN,
New York, N. Y. Transit Commission.
Nov. 9, 1936.

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Editorial offices at 330 West 42nd Street, New York

January 28, 1937

Clear the Flood Channels!

SECOND GREAT FLOOD wave to sweep down the Ohio in the wake of the drought stages of 1932, the current week's unparalleled high water places flood control in the forefront of public concern. The news of the day leaves no doubt that the only way to lessen the huge flow of water is to hold it back in reservoirs. But to build these reservoirs is an undertaking of tremendous magnitude; now that every river is full, from Muskingum and Kanawha to Tennessee and Wabash, it can be seen that so many reservoirs will be needed as to make effective control a matter of decades rather than years. And even the most extensive reservoir system will never curb the Ohio so completely as to keep dry the bottomlands and flood-plain flats over which high water has flowed since the river first carved out its course. And meanwhile the occupation of flood channels by houses, factories, and other human works continually raises the flood level and endangers other communities. Human life and security require that the flood channels be kept unthrottled. Up to now nothing has been done to guard them, but the time has come to take the first step toward flood security by clearing the bottomlands. Riverbank squatter cabin or factory, all trespassers on the high-water channel should be ejected and the flow zone guarded as zealously as harbor waters. Let us go forward with flood control by all means at hand, but first of all clear the flood channels!

Construction in the Movies

THE NEWSREELS are not strangers to construction, and now and again some producer bored with Park Avenue bedroom scenes tries his hand at mixing hoists, derricks and love. But it remained for the U. S. Steel Corp. to turn out the first authentic construction movie. The sound film portraying the building of the San Francisco-Oakland Bridge that was shown to the Civil Engineers last Thursday is worthy of some superlatives. If it is the forerunner of more such films to come this journal may have to add a dramatic critic to its staff; he might write of the present performance in some such terms as these:

> The new film starring Harry Hunter and his American Bridge Co. band of riveting artists in their epochmaking and successful efforts to build the world's greatest bridge is a high spot of the winter season. Portrayed against a background of San Francisco skyscrapers and Oakland suburban hills in a locale high above the waters of the Bay, the construction operations benefit from honesty and dramatic quality in both direction and photography. The sound effects are realistic, particularly the cow bell that heralds the approach of the spinning wheel to workers on the catwalks. The spectacular character of cable-spinning operations led the producers rather naturally to emphasize this phase of the work but veteran construction men will regret the omission of a great many interesting scenes in the erection of the 1800-ft. cantilever span. The acting of the principals as well as of those in minor parts was notable for its sureness and gave rise to the hope that we shall see some of them again in more conspicuous roles. As an educational film both for the layman and for sedentary engineers who shun catwalks and falsework bents, the cinema construction of the Bay Bridge has not been equaled.

And if such a review were written, we can testify from personal observation that it would have to be rated as remarkably accurate.

Power Policy

THE PRESIDENT has named a special power policy committee to report to him within a few weeks on what should be the nation's policy on power matters. Though appointment of the committee is generally looked upon chiefly as a move toward finding a way to end the Morgan-Lilienthal controversy in the TVA, it is to be hoped that it will result in defining what policy the Administration is going to adopt with respect to all its power undertakings. There is no such policy now. Had there been one in 1933 the government would not now be in the position of having a big power plant on its hands at Bonneville for which no use has yet been discovered. Regardless of one's views as to the desirability or undesirability of the government going into the power business, everyone must admit that the first essential to any step of such importance is to lay down a policy to be followed. Months ago a committee was set up to formulate such a policy, but to date it has produced nothing concrete. The country should not continue to muddle along. After all, the TVA situation is a local one; what the nation needs is a national policy, clearly defined and closely adhered to. In establishing it, it is to be hoped that the broad social view promulgated by Arthur Morgan last week will prevail.

Analysis and Dollars

AS A DEMONSTRATION of the dollar value of analytical method in the planning of construction projects, Julian Hinds' brilliant monograph on water conduit economics takes high rank. If an aqueduct system is to be built at lowest over-all cost, the calculation process which he sets forth is indispensable, for even the best-trained judgment is incapable of attaining the desired result. Since the reasoning applied in the analysis is unaffected by lapse of time or improvement of construction method, the article claims a place in the handbooks as a standard of hydraulic procedure. At the same time it should be remembered that no procedure of the kind can be used without judgment based on all influencing factors. Selection of elevation controls and determination of the variation of tunnel cost with size are two matters in point. Another is the case of greatly variable flow, when peak capacity is required for only a small part of the time and when it can be obtained by increasing the initial pumping head and operating the upstream part of the line under pressure during the time of maximum demand. There are many points of judgment to be remembered in applying analytical procedure to dollars.

Equipment Makers Keep Pace

THE FACILITY with which construction equipment manufacturers keep pace with the changing needs of the engineer is brought to mind by the letter of H. L. Stilley, published in this issue, in which he notes the changes that have been made in grading equipment built by his company. In the last few years engineers have discovered that much greater refinement is needed than heretofore was applied to embankment construction if the fill is to attain the best possible form. This calls for

greater uniformity in spreading than was economically possible five years ago. But the grading equipment manufacturers have followed the findings of soil mechanics and now are prepared to meet the more exacting requirements. What is true of grading equipment is true of other types. The manufacturers continually are watching the developments of new needs in order to improve existing equipment or develop new types.

A Difficult Assignment

RECENTLY Arthur S. Tuttle, PWA director for New York, announced that he is asking all public authorities to plan improvements far in advance, so that a reservoir of well-planned projects may be available for emergency use in the future. His demand is a timely reminder of a highly important objective of advance works planning, one that ought never be left out of mind. It represents a difficult assignment, however, for improvement works almost always are planned for definitely existing needs, and it is never easy to foresee needs that are not yet here nor to develop the requisite interest and data for proper planning to meet them. Probably the only effective way to accomplish the desirable end of having a reservoir of projects ready for emergency use is to keep improvement planning at all times eight or ten years ahead, scheduling the work according to the urgency of the individual project and revising and extending the plan each year. Mr. Tuttle's call defines an obvious duty of works officials.

Flood Drama

WITH SURPRISING SUDDENNESS winter rains have sent an unprecedented floodwave down the Ohio, and as we write there is prospect of a flood in the Mississippi rivaling the 1927 disaster, the disaster that caused Congress to make the protection of the Mississippi Valley a national undertaking. The works built as a result of that decision are now being put to test; within the next two weeks nearly every major part of the Mississippi flood control works will be under critical flood attack.

Everyone is scanning the daily reports to see how the key elements of these works meet the test. Leading questions are: Will the new levees hold? Will the bypasses work? And what of the new cut-offs, especially those through the tortuous Greenville bends?

In essence the protective system built since 1928 consists of a new, much higher and stronger levee system from Cairo to the Gulf, supplemented by bypasses that divert part of the water at four points where the leveed channel could not carry all the water. Three hundred million dollars has been spent. Practically all of the heightened levees have been completed; two of the diversion bypasses have been built and a third is partly completed; the fourth is not yet started—and just now this means drama, perhaps tragedy.

Worst danger point on the river is Cairo, a city built on a tongue of sand between the Ohio and Mississippi at their junction. Cairo's streets are 40 ft. above low water but high floods go up to 60 ft. The city is ringed in by an earthen wall whose top is at 60; will this wall fail? To protect Cairo from being drowned out in the very great floods, a wide bypass floodway has been created on the west bank of the Mississippi, beginning just opposite the city at Birds Point and continuing some 20 mi. down to near New Madrid. The levee at the head of the bypass is intended to wash out when the water nears 60 ft. On Jan. 25 this fuseplug levee was dynamited. Will it lower the flood level enough to save Cairo?

Near the extreme lower end of the river is New Orleans, also below flood level and always in fear of submergence in extreme high water. To protect it, the Bonnet Carré spillway was cut through into Lake Pontchartrain—a mile-wide channel barred by a weir at the river end. Bonnet Carré is expected to keep the river at New Orleans from rising above 20 ft. on the gage, a safe level. It awaits its first test.

Further to protect the New Orleans-Baton Rouge section of the river, about half the floodflow is tapped off some 200 mi. above, partly through Old River and partly through a controlled spillway at Morganza, into the Atchafalaya. The Old River entrance is ready and will probably take all the water that needs to be diverted; Morganza spillway has not yet been built. What will happen along the overloaded Atchafalaya?

In the long stretch south of the Arkansas River the Mississippi's leveed channel cannot carry the greatest floods. Some of their water was to be diverted down to the Red and Atchafalaya through the lowlands of Bayou Boeuf; but the army engineers' attempt to dedicate these lands to floodway service without paying for them blocked the plan, so that Congress last year authorized Gen. Markham to substitute a floodway through Bayou Tensas, heading at Eudora. The Eudora floodway has not yet been started, and meanwhile the levees at the head of Bayou Boeuf have been left at the old low height, to function as "fuseplugs". If the river gets very high, watch for a crevasse discharge here.

There are local elements of life-and-death interest—river walls or ring levees at such points as Hickman and Monroe, backwater flooding in the Yazoo, St. Francis, and Tensas regions, and the local levees that protect the bottomlands along the back streams of the basins. But these are not part of the big Mississippi-guard works.

However, superadded to the project adopted by Congress in 1928 is the great series of cutoffs planned and built by Gen. Ferguson in the last four years. A dozen snakelike bends of the river have been eliminated by these cutoffs. Described by George R. Clemens after their virtual completion last spring (see *ENR* Feb. 20, 1936, p. 269) they are a proved success at low water and in moderate floods, increasing the river discharge capacity by hundreds of thousands of second-feet. In ordinary high waters they have lowered the river stages by 6 or 7 ft. Will they do the same in a great flood? If so, they may help to save the Bayou Boeuf region from deluge. But again, will the cutoffs produce destructive flood currents that will attack the levees?

Other large river works will be on trial in the flood—miles of costly sand-dike training walls below Greenville, and spur-dikes in the region above Memphis—but these should not affect the major flood events. The decisive questions are whether the high levees, not yet wetted by a great flood, will hold; whether their grade line proves to fit the crest elevations of the flood wave; whether the cutoffs abreast of the Tensas Basin will save the Boeuf Valley; and whether the Birds Point and Bonnet Carré diversions will relieve the threat to Cairo and New Orleans.

These are the outstanding elements in the developing drama of the Mississippi flood. The coming weeks promise to tell the story.

CURRENT NEWS

Floods Break All Records In Lower Ohio Valley

Long period of unusual rainfall raises river crests to ten feet above previous records—Water supplies and power services crippled in all small towns and most large cities along the lower Ohio

FLOODS that have already exceeded many previous records by nearly ten feet are sweeping down the Ohio River as this issue goes to press. Due to mild weather conditions that turned to rain a long-continued precipitation that normally would have fallen as snow, water has been high in the river since early January. By the middle of the month the Ohio was up to or above flood stage at many points but there was no reason to expect abnormal floods. Then came an unusual meterological happening almost identical with the happening that resulted in the floods in the upper Ohio tributaries, in New York, and in New England last March.

A high pressure area moving southeasterly across the Great Plains was counterbalanced by a similar area over the Atlantic. Both remained almost stationary for over a week, during which period the warm, moist air over the Gulf of Mexico was drawn up the Mississippi and Ohio valleys where, upon meeting the cold air of the western high-pressure area, a contact zone brought continuous heavy precipitation. Unlike last March, when similar conditions resulted in heavy precipitation along the crest of the Allegheny Mountains, the contact zone was farther west and coincided almost exactly with the Ohio valley. During the period Jan. 7 to 25 Louisville had 18.27 in. of precipitation, *more than four times the normal* for the entire month of January. Cincinnati in the same period had 13.15 in., and other stations in the Ohio drainage basin reported similar records.

Conditions become serious

Ten days ago the Ohio was a little above flood stage at Pittsburgh but conditions were not alarming. Farther down the river, water was high in the tributaries, and to the west of the Mississippi the White and St. Francis rivers were in flood and minor levee lines had been broken, but there were no indications that serious conditions would develop. However, precipitation continued general over a wide area, and little of it fell as snow or was held by freezing weather.

By Jan. 21 it became apparent that the flood runoff from the upper tributaries would reach the lower Ohio about the time that the lower tributaries would be at their maximum and that the lower river would be required to carry flows equal or exceeding past records; also that these flood flows, augmented by high flows from the Tennessee and the Cumberland, would pass into the Mississippi at Cairo, causing abnormally high floods there and putting to its first test the system of flood protection works located on the lower Mississippi.

Because of the seriousness of the flood situation, and in recognition of the fact that the many engineers upon whom this journal could normally count for reports on local conditions would be fully absorbed in the flood relief work, *Engineering News-Record*, on Jan. 22, started two editors to the flood area, W. W. DeBerard from Chicago and H. W. Richardson from New York. Mr. DeBeard made an extensive study of the Mississippi River flood of 1927 and since then has kept in close touch with the plans under which the Birds Point-New Madrid floodway and the Boeuf floodway were built and the levees raised (except in the so-called fuse-plug at the upper end of each floodway). Mr. Richardson reported the flood in the Ohio and its tributaries last March and is familiar with conditions in that valley. The first reports from Mr. Richardson are given elsewhere in this report.

FLOOD STAGES IN THE OHIO

Location	Predicted Maximum	Stage Jan. 25 or later	Previous Record	Date
Pittsburgh	35	29.8	46	1936
Wheeling	50	44.8	55.5	1936
Point Pleasant	62	60.3	62.8	1913
Huntington	68	66.0	65.3	1913
Portsmouth	74	72.8	67.9	1913
Cincinnati	81	80.0(1/26)	71.1	1884
Louisville	58	54.8	46.7	1884
Evansville	55	50.8	48.8	1884
Paducah	61	....	54.3	1913
Cairo	61	58.4	56.9	1927

Telegraphic inquiries also were addressed to engineers who could advise as to conditions at key points of engineering interest such as the Great Miami River valley with its complete system of flood-control reservoirs, the Muskingum valley where a similar flood-control system is being built, and the Tennessee River valley, as well as to the Washington offices of the Army Engineers, the Weather Bureau, and the Geological Survey, and to the Mississippi River Commission at Vicksburg. Information from these sources is included in the following reports.

Expected flood crests

Flood stages in the lower river are expected to go to nearly 10 ft. above the previous records. As this is written (Jan. 26) the level at Cincinnati is reported stationary at 80 ft., or nearly 9 ft. above the record of 1884; a crest stage of 81 is expected. Stages at other points are given in the accompanying table.

At Pittsburgh, where the river began rising again after the minor flood peak of last week, the crest passed on Jan. 26, reaching a maximum of 34.5 ft., about equal to the highest floods prior to 1936 but 11½ ft below the all-time record established last year.

At Wheeling, where such extensive damage was done on Wheeling Island last year, it appears that the flood crest will reach last year's record. Evacuation of the island has been ordered.

From the table it will be seen that last year's flood did not attain the 1913 record below Wheeling. As a result, at Portsmouth, the famous wall that was built to protect the city from flood up to the 62 ft. stage (*ENR* May 7, 1936, p. 669) was not overtopped last year. This year's flood went 10 ft. over the top of the wall, it had attained a level of 72.8 by Jan. 25 and is expected to go to 74 before the crest is passed.

Information concerning points lower down the river is in separate reports.

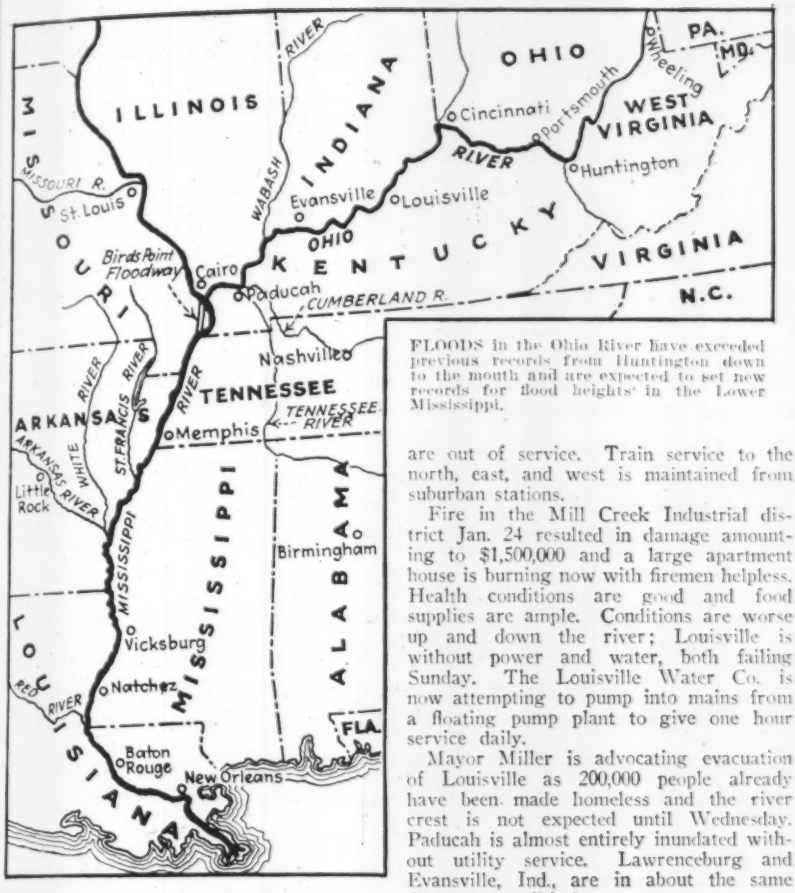
The TVA reports that an average flow of 33,000 sec.-ft. has been held back at Norris Dam for the past ten days and that the flood gates have been raised to hold back flood flows from the Clinch River basin. This reduced the main river crest at Chattanooga by two feet. The cofferdam at Guntersville dam has been flooded and that at Pickwick Dam is in danger. The pool back of Wheeler Dam is full.

The Muskingum River reached a crest of 37.6 ft. on Jan. 26, 12.6 ft. above flood level and 5 ft. above the flood crest of August, 1935, according to Major Joseph D. Arthur, district engineer at Zanesville. The maximum flow at Zanesville then was 138,000 sec.-ft. Eleven of the fourteen dams now under construction acted as retarding basins, with an estimated reduction in flood heights of 3 ft. at Zanesville. Three of the completed dams could not be operated by closing the gates because the reservoir land had not yet been acquired.

Mississippi River

The strengthened levee system on the Mississippi River is up to the project grades, according to the Mississippi River Commission. Below Cairo, the Birds Point-New Madrid floodway was brought into action on Jan. 25 when the Army Engineers began blasting the fuse-plug levee at the head of the floodway. Because this is formed of the old well compacted levee it does not erode rapidly, and as a result only 40,000 sec.-ft. were flowing into the floodway which is designed to carry 400,000 sec.-ft. Dynamiting is being continued. The floodway is formed by two dikes about 10 miles apart and designed to keep the overflow from spreading over the whole area, returning it to the river near New Madrid.

Despite the small quantity going into the floodway the gage at Cairo dropped slightly on Jan. 26 though the flow in the Ohio was increasing. The levee tops at Cairo theoretically are at 60 ft. on the gage; the crest stood about 59 ft. at midnight Jan. 25. Actually the top can be held up to about 62 ft.



FLOODS in the Ohio River have exceeded previous records from Huntington down to the mouth and are expected to set new records for flood heights in the Lower Mississippi.

Conditions at Cincinnati

By H. W. Richardson

Cincinnati, Jan. 25

The Ohio valley from Huntington to Cairo is in the grip of the worst flood on record. The river still is rising along its entire length following rain on Jan. 24 of from 1 to 2.7 in. between Louisville and Pittsburgh on top of 6 in. of snow. The river at Cincinnati at noon on Jan. 25 stood at 79.5 ft. with 81 ft. predicted late Tuesday night. Flood stage here 51 ft. and the previous high was 71.1 ft. in 1884. The city is under semi-martial law on an emergency basis, with all business stopped and only drug and food stores open, no street car service and only a skeleton bus service. The city pumping plants were flooded Sunday afternoon when the flood reached 75 ft., leaving only 100 million gallons in reservoir. Water is shut off except two hours daily and yet one fourth of the reserve already is gone. Water situation is desperate and plans are being made to haul in by tank truck enough to keep the hospitals and refugee stations going.

Columbia Power Plant of the Union Gas & Electric Co. failed Sunday afternoon and the West End Station went out early Monday leaving the city without power except emergency supply from Dayton and Indianapolis, which is sufficient only for limited use in business district.

The Union Terminal is surrounded by water and is used only by the Southern and C. & O. shuttle service to the Kentucky shore. All highway bridges to the south are out of service. Train service to the north, east, and west is maintained from suburban stations.

Fire in the Mill Creek Industrial district Jan. 24 resulted in damage amounting to $1,500,000 and a large apartment house is burning now with firemen helpless. Health conditions are good and food supplies are ample. Conditions are worse up and down the river; Louisville is without power and water, both failing Sunday. The Louisville Water Co. is now attempting to pump into mains from a floating pump plant to give one hour service daily.

Mayor Miller is advocating evacuation of Louisville as 200,000 people already have been made homeless and the river crest is not expected until Wednesday. Paducah is almost entirely inundated without utility service. Lawrenceburg and Evansville, Ind., are in about the same desperate condition.

The army engineers are greatly concerned about the lower Ohio from Cincinnati down, especially Louisville, Mound City and Cairo. The New Madrid floodway went into operation yesterday but may not affect Cairo crest in time to save the city. The stage at Cairo now is 58.2. The high mark in 1927 was 56.4. The army engineers see little hope for Mound City, Cairo and Shawneetown. They are establishing a river base at Golconda, Ill., for patrol and rescue work. Many smaller towns are isolated and in desperate situation. This is true of the whole valley.

Upstream, Portsmouth is the worst hit with the present stage of 71.6 ft. or 10 ft. above the flood wall. Martial law is in effect as four-fifths of the city is inundated. Citizens are being removed to Columbus by the Red Cross but this is difficult because of washed out roads and railroads. At Huntington the stage is now 66 ft., eclipsing the 1913 record of 65.3. Wheeling Island again has been evacuated as the river rises to 44.8 or 10½ ft. below record of last March.

Peak Near at Cincinnati

Cincinnati, Jan. 26

The river at Cincinnati is practically stationary at 80 ft. this morning but a stage of 81 is expected tomorrow. The tributaries and the main river upstream are reported to be falling.

Cincinnati's water supply is practically exhausted and is being doled out for only a few minutes each day. Plans now are being made to haul it in from outside and to draw on industrial wells within the city. The waterworks cannot be operated until the river is down to 70 ft., or for a week.

Portsmouth still has power and water one hour out of six. Louisville is reported as under martial law with 230,000 homeless and neither water nor power. Farther downstream the situation is most acute. The Army Engineers are evacuating Paducah and Shawneetown and expect to aid at Evansville. Battalions of engineers are building pontoon bridges and other temporary access to the rear of the stricken town. The department's floating plant and rented equipment is all engaged in rescue work below Louisville.

Lieut. Col. Eugene Reybold, district engineer at Memphis, declares that the Mississippi levees at Cairo are good for a crest of 62 and the present expectation is 60 ft. The gage at Cairo stands at 58.4 ft. with the floodway now coming into action.

River discharges

Available figures as to river discharges and drainage areas are as follows: Cincinnati, 1,000,000 sec.-ft. from a drainage area of 76,500 sq.mi.; Cumberland River, 300,000 sec.-ft. from 18,000 sq.mi.; Ohio at Cairo, 2,200,000 sec.-ft. from 204,000 sq.mi.; Mississippi below Cairo, 2,500,000 sec.-ft., which is 300,000 ft. above the figure used in developing the flood plan.

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Great Miami Valley Floods Sharply Cut by Dams System

The only comprehensive flood-control system in the Ohio Valley, the Miami Conservancy system, met a severe test at peak flow of the Great Miami River system last week. It functioned with entire success, according to a wire statement of C. H. Eiffert, chief engineer of the Conservancy District.

Eleven-day rainfall at Dayton (Jan. 13-24), representative of precipitation conditions over the river basin, totaled 9.59 in. The five retarding dams of the system impounded water to the following depths.

Englewood	54.7
Germantown	51.8
Taylorsville	26.9
Huffman	24.9
Lockington	29.7

These stages were exceeded at different prior occasions at the several dams but the combination of reservoir discharges exceeded that ever before experienced. On Jan. 15 the river at Dayton reached a stage of 14.6 ft., at Hamilton 17.4 ft., the highest stages attained in the 12 years since completion of the conservancy works. The peak discharge at Dayton was 53,000 sec.-ft. Without control by the retarding dams it is estimated that the discharge would have reached 90,000 sec.-ft., or about that of the 1898 flood, second only to the great 1913 flood.

No damage was done to the District Works or to the property protected. Without control the flood would have caused extensive damage.

Hopeful Conditions at Cairo

By W. W. DeBerard

Cairo, Ill., Jan. 26

The Cairo gage at noon today stood at 58.36 or three-tenths lower than the maximum Monday at 6 p.m. Forecaster Barron predicts that it will not go

(*Continued on page* 144)

Truck Regulation Invalidated

South Carolina federal court outlaws drastic state regulation of size and weight of trucks

Enforcement of a South Carolina law limiting the width of trucks to 90 in. and their weight to 20,000 lb. was enjoined on Jan. 20 by the federal circuit court of appeals at Columbia, S. C. The court held that, though the law might reasonably apply on unpaved roads, the state must be permanently enjoined from enforcing the law on the main highways of the state.

It was held that the South Carolina restrictions, which are more rigid than those of any other state, constitute an unreasonable burden upon interstate commerce. Truck operators had maintained that they could not operate successfully in South Carolina if the law were enforced, declaring that most of their trucks are heavier and wider than the law allowed.

The court gave some weight to the fact that federal-aid funds had been used in construction of the state highway system, holding that enforcement of the state law would defeat the purposes of federal aid in establishing a national network of highways. The opinion said that it would be unreasonable under these circumstances for South Carolina to put a wall about itself.

The law has never actually been enforced, its enforcement having been enjoined until now by temporary restraining orders.

Death of John H. Gregory Ends Notable Career

John H. Gregory, consulting engineer, Baltimore, and professor of civil and sanitary engineering at Johns Hopkins University, died on Jan. 18 at his home in Baltimore, while preparing to leave for the annual meeting of the American Society of Civil Engineers. His unexpected death at the early age of 62 cut short an active and distinguished career in the field of water supply and sanitation. He had been engineering adviser to many cities and other governmental authorities, and in addition to building many municipal works had contributed to the literature of the profession.

John Gregory received his technical education at the Massachusetts Institute of Technology (1895). Beginning his engineering practice in the service of the Boston metropolitan water board, he later was associated with Allen Hazen on various water supply projects, was engineer for the Jersey City Water Supply Co., the commission for additional water supply of New York City, and the metropolitan sewage commission, and finally entered into partnership with the late Rudolph Hering, under the firm name of Hering & Gregory, in consulting sanitary engineering practice.

The partnership was dissolved in 1917 when Prof. Gregory was commissioned as a captain in the sanitary corps of the army. In 1920 he was chosen professor of civil and sanitary engineering at Johns Hopkins University, in which position he remained until his death. He continued his engineering practice, however, and was frequently called to serve as member of special boards, notably the engineers advisory board of the Reconstruction Finance Corporation four years ago.

John H. Gregory

Throughout an active engineering life, Prof. Gregory contributed extensively to the literature of the profession. A number of articles from his pen appeared in the columns of *Engineering News-Record*, and he presented many important papers before the technical societies. He was awarded the Rowland prize (1910) and the James Laurie prize (1930) for outstanding papers delivered before the American Society of Civil Engineers.

Prof. Gregory's practical qualities were coupled with an intensely studious and inquiring mind. He was early identified with great engineering works at Albany, Philadelphia, Jersey City, and New York and was a consultant to Columbus, Ohio, for a quarter of a century. He was a keen analyst, yet his designs always bore the mark of eminently practical judgment.

John C. Page

John C. Page Named To Head Reclamation

Succeeds the late Elwood Mead after serving as Acting Commissioner for past year

On Jan. 25 John C. Page was appointed Commissioner of Reclamation in the U. S. Department of the Interior by Secretary Harold L. Ickes, after having carried the responsibilities of the position with the title of Acting Commissioner of Reclamation since shortly after the death of the late Dr. Elwood Mead on Jan. 26, 1936 (*ENR* Jan. 30, 1936, p. 173).

John C. Page, born at Syracuse, Neb., in 1887 and educated at the University of Nebraska and Cornell University (civil engineering and hydraulics), entered the Reclamation Service in October 1909, and with a brief intermission while serving in the city engineer's office at Grand Junction, Colo., has continued with the Reclamation Bureau ever since. He served as engineer and assistant superintendent on the Grand Valley project, Grand Junction, and in 1925 was made superintendent, succeeding S. O. Harper. In 1930 he was appointed office engineer at Boulder City, Nev., in which position he was chief administrative assistant to Walker R. Young, engineer of construction on Boulder Dam.

In 1935 Dr. Mead called Mr. Page to Washington as head of the engineering division, from which work he was called to conduct the Bureau as Acting Commissioner last February.

Hopeful Conditions at Cairo

(*Continued from page* 143)

higher than 60 or 61. The levees and seawall with their top at 60 were being bulkheaded up two feet on Tuesday and another foot will be added Wednesday, with a further eighteen-inch raise possible. Consequently Cairo which has kept dry for eighty years feels safe although some four thousand women and children have heeded repeated warnings to leave the city.

The fuseplug section of the Missouri levees which were not yet lowered to the project level of fifty-five feet, but have remained at fifty-seven or fifty-eight, began to break at 10 a.m. Sunday morning in two places above and below the 1927 break at Dorena. Dynamiting of the fuseplug began Monday and was continued Tuesday causing openings in five places. The result was a lowering of the Cairo gage three-tenths of a foot as well as caring for the rise caused by higher gages upstream.

The Ohio River levee at Cairo from the Illinois Central bridge to its junction with the Mississippi River levee was greatly strengthened in 1932 and this year by sheetpiles twelve to fifty feet long. In addition, cellular concrete earth-filled walls, ten feet wide on top, have given excellent foundation for a bulkhead. Sheet piling has materially reduced the incidence of sand boils.

The President Seeks A Power Policy

Washington Correspondence

Appointment by President Roosevelt of an informal committee to formulate a national power policy covering the generation, transmission and distribution of power from Bonneville dam and all other federal projects appears to come as a more or less direct result of Arthur Morgan's statement of last week (*ENR*, Jan 21, 1937, p. 101) advocating the pooling of public and private power resources. The President's committee, consisting of Secretary of the Interior Harold L. Ickes; Frederic A. Delano, vice-chairman of the National Resources Committee; Robert E. Healy, commissioner of the Securities and Exchange Commission; Morris L. Cooke, administrator of the Rural Electrification Administration; and Frank R. McNinch, chairman of the Federal Power Commission, was appointed on Jan. 18 and was asked to submit recommendations within a couple of weeks.

Morgan's statement

Publication of the Morgan statement precipitated an open division between that faction of the government advocating competition with the utilities and the setting up of yardsticks and those who favor more moderate methods. The same issue was raised last fall at the expiration of David Lilienthal's first term as TVA director, when Chairman Morgan threatened to resign if Lilienthal should be reappointed. The President succeeded at that time in reconciling the disputants and the reappointment was made without open objection.

Although the Morgan statement was issued without explanation, it was apparently inspired by the imminent expiration on Feb. 3 of the interchange agreement between TVA and the Commonwealth Southern system, which was extended to that date in the hope of reaching an agreement for the pooling of generating and distribution facilities in the Tennessee Valley. It is rumored that these negotiations had come to a complete deadlock and that no further extension of the interchange agreement was contemplated. It is believed that Mr. Morgan issued his statement in the hope of so arousing public support for his moderation policy as to force the continuance of the negotiations.

Issues are generalized

It would appear that the appointment of the new informal committee is an escape from the situation facing President Roosevelt in which he would be forced to side with one of the two disputants and thus immediately define his future attitude toward the utilities. The President stated that the completion this year of the Bonneville project on the Columbia river renders it highly important to formulate a national power policy for all federal projects uniform as to principal although, of course, not necessarily so as to rates.

By thus transferring the problem away from this one particular dispute and from the Tennessee Valley, the President avoided the implication which would have been read into any action favoring one or the other of the disputing TVA directors. Also the future power policy of the TVA was not the only point at issue; Mr. Morgan's statement involved also the policies of the federal government in marketing power from many other sources, the policy of assisting municipalities to construct competitive power systems through federal loans and grants; and the relative importance of power in the TVA objectives.

Ultimately, of course, a decision must be made between the Lilienthal and Morgan objectives. But the conclusions of the new committee will be based, not upon TVA, but upon the entire picture, with emphasis on the Bonneville problem.

THIS PWA HOUSING project in Miami, Fla., is typical of the three Southern projects which have been completed during the past week. The average rental on this project will be $5 per room per month.

Drainage Basin Report To Be Made Public

The report on the drainage basin studies of the National Resources Committee carried on during the past year by a special organization under the direction of Frederick H. Fowler, San Francisco, is to be submitted to Congress shortly, according to an announcement by the President. The report will present lists of water utilization and development projects for the 127 stream basins studied, including all types of improvement such as navigation, flood control, power development and sanitation.

Projects have been listed as either immediate or deferred, and have been placed in order of priority as determined by the judgment of the committee. The listing is said to be intended to guide in intelligent selection of projects whether for federal, state or local construction, or private enterprise. Some preliminary discussion of the scope of the report was included in the meeting of the American Society of Civil Engineers last week, as reported on p. 136 of this issue.

Wellwood to Handle Power For Nebraska PWA

Arthur R. Wellwood, formerly regional director of the Federal Power Commission's newly established office at Atlanta, Ga., has been appointed supervising engineer and placed in charge of all PWA power projects in Nebraska, effective Jan. 16, according to an announcement by PWA Administrator Ickes.

Low Rentals Achieved On Housing Project

Three new PWA public housing projects were opened last week with rentals as low as $4 per room per month. This is a sharp drop from the average of $7.39 per room per month which was found necessary at Techwood homes in Atlanta, Ga., the first of the PWA housing projects to be opened. (*ENR*, July 16, 1936, p. 100).

Rentals are lowest at the Paterson Court project in Montgomery, Ala., a negro housing development. Homes in this project will rent for an average of $2.00 per week for two rooms, up to $4.50 per week for five rooms. This project consists of group houses occupying about one-fifth of the land area with each house provided with a private yard. The houses are only two rooms deep, and all apartments will enjoy cross ventilation. Each apartment has a kitchen and bath.

Riverside Heights, the other PWA housing project in Montgomery, Ala., will have somewhat higher rents. A two-room apartment in this project will rent for an average of $13.50 per month, and a five-room apartment for $24 per month. The average rental on the project will be $6.33 per room per month. Apartments here are also arranged in group houses. Apartment walls are of plaster with wooden floors; steel casement windows provided with screens are used and vermin-proof metal trim is used in all rooms.

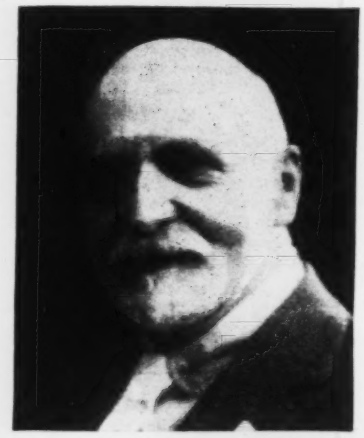
The third project opened last week, Liberty Square, is in Miami, Fla., on the outskirts of the city. The average rental on this, the fourth PWA project to be completed, of $5 per room per month, is based on a range of rentals from $2.85 per week for a two-room apartment to $5.25 per week for a five-room apartment. The project is composed of group houses built of 8-in concrete block walls and intended to be hurricane-proof. The dwellings, which are one-and two-story group houses, are an adaptation of the Bermuda type architecture, with white shingled roofs and stucco exterior. Each apartment is provided with sanitary equipment, modern ice box, oil stove, and running hot and cold water. A community building containing an auditorium and a day nursery is included in the project.

Elections to Honorary Membership in A. S. C. E.

FIVE men were elevated this year to honorary membership in the American Society of Civil Engineers. They were Alex Dow, president of the Detroit Edison Co.; George H. Duggan, chairman of the board of the Dominion Bridge Co.; Robert Hoffmann, consulting engineer for the division of engineering and construction for the city of Cleveland; J. B. Lippincott, consulting engineer, Los Angeles; J. A. L. Waddell, consulting engineer, New York.

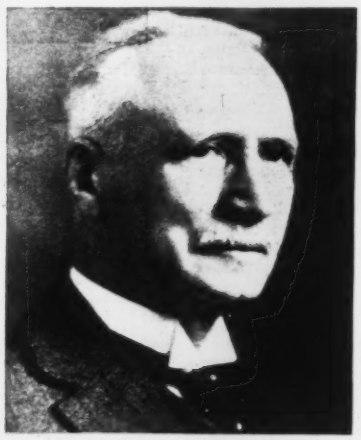
A brief account of the careers of the new honorary members follows:

ALEX DOW was born in Scotland and came to America in 1882 at the age of 20, soon entering the telegraph department of the Baltimore & Ohio R. R., remaining in that work until 1888. He then became connected with the Brush Electric Co. and three years later was put in charge of the construction and design for the lighting of Chicago's South Park system. The following year he was engaged as municipal engineer to design and build a lighting plant for Detroit. Three years later Mr. Dow resigned to become vice-president and general manager of the Edison Illuminating Co. of Detroit and president of the Edison Sault Electric Co. Later the Detroit Edison Co. took over the earlier organization, and in 1912 Mr. Dow became president of that company, which position he still holds.



Alex Dow

GEORGE H. DUGGAN first taught at the University of Toronto after graduation in 1883. Two years then were spent in the employ of the Canadian Pacific Ry. on location and bridge construction, and in 1888 he became a resident engineer for the Dominion Bridge Co. In 1891 Mr. Duggan was made chief engineer of that company. He later left that company to become connected with the Dominion Iron & Steel Co. and the Dominion Coal Co. and was for six years vice-president and general manager of the latter organization. Returning to the Dominion Bridge Co., he became its president in 1918. He has recently resigned from that position and from the presidency of the Dominion Engineering Works to become chairman of the board of both companies.



George H. Duggan

Robert Hoffmann

ROBERT HOFFMANN was born in Cleveland in 1865. He graduated from Hiram College in 1885 and from the Case School of Applied Science in 1893. The same year Mr. Hoffmann entered the engineering department of the city of Cleveland. After a series of promotions he was appointed, in 1907, commissioner and chief engineer of the division of engineering and construction. He has acted as consulting engineer for the division since 1930.

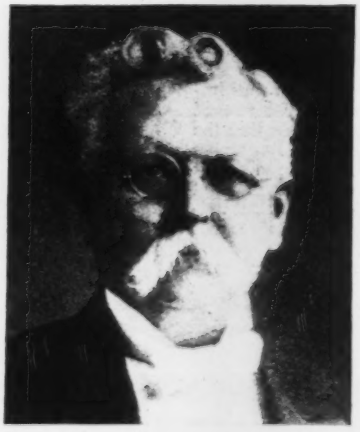
J. B. LIPPINCOTT was a graduate in 1886 of the University of Kansas. The same year he began his engineering work with the Atchison, Topeka & Santa Fe Ry. Two years later he became a topographer in the U. S. Geological Survey for four years and was later assistant engineer of the Bear Valley Irrigation Co. in California. In 1893 he returned to the service of the Geological Survey as hydrographer for California, and held this position until 1902 when he was made supervising engineer for the U. S. Reclamation Service in charge of the Pacific Coast District. In 1906 Mr. Lippincott resigned from the reclamation service to take the position of assistant chief engineer of the Los Angeles Aqueduct.

In 1913 Mr. Lippincott opened offices in Los Angeles to practice consulting engineering, specializing in water supply and irrigation work. He has practiced throughout the western states, Alaska, Mexico and the Hawaiian Islands since that time.

J. B. Lippincott

J. A. L. WADDELL, after his graduation in 1875 from Rensselaer Polytechnic Institute, was employed for a year by the Canadian Pacific Ry. as a field engineer. He then taught for a year at Rensselaer, and in 1878 became chief engineer of the bridge building firm of Raymond & Campbell. Two years later he became professor of civil engineering at the Imperial University of Japan, staying there for four years. Mr. Waddell entered private practice in Kansas City in 1887 as a partner in the firm of Waddell and Hedrick; the firm was reorganized in 1899 as Waddell & Harrington, and more recently as Waddell & Hardesty. (*Continued on next page*)

J. A. L. Waddell



Wide World Photo

FRITZ MEDAL AWARDED AT MEETING

THE JOHN FRITZ MEDAL being presented to Arthur N. Talbot by the American Society of Civil Engineers at the annual meeting Jan. 20. In the photo, left to right, are: Arthur N. Talbot; Arthur S. Tuttle, PWA state engineer for New York and chairman of the John Fritz medal board of award; Harry P. Charlesworth, vice-president, Bell Telephone Laboratories, presenting the medal; and Alonzo J. Hammond, consulting engineer, Chicago.

In the course of his consulting practice, Mr. Waddell has been retained as a consulting engineer on bridge work in China and has served as an adviser to the Chinese government. Mr. Waddell is the author of "Economics of Bridge Work" and "Bridge Engineering."

SOCIETY CALENDAR

ASSOCIATED GENERAL CONTRACTORS OF AMERICA, annual convention, San Antonio, Texas, Feb. 15-17.

AMERICAN CONCRETE INSTITUTE, annual meeting, New York, N. Y., Feb. 23-25.

HIGHWAY CONFERENCE, UNIVERSITY OF ILLINOIS, Urbana, Ill., March 3-5.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, annual meeting, Chicago, Ill., March 16-18.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS, annual meeting, New Haven, Conn., Feb. 16-17.

SOUTHWEST ROAD SHOW AND SCHOOL, Wichita, Kansas, Feb. 23-26.

ASSOCIATION OF HIGHWAY OFFICIALS OF NORTH ATLANTIC STATES, annual convention, New York, N. Y., Feb. 24-26.

MINNESOTA FEDERATION OF ARCHITECTURAL AND ENGINEERING SOCIETIES, annual convention, St. Paul, Minn., Feb. 26-27.

NEW YORK STATE ASSOCIATION OF HIGHWAY ENGINEERS, annual convention, Albany, N. Y., March 4-6.

NEW JERSEY SEWAGE WORKS ASSOCIATION, annual meeting, Trenton, N. J., March 11-12.

Officers elected by the COLORADO SOCIETY OF ENGINEERS at its annual meeting in Denver, Jan. 15-16 include: president, Dan J. McQuaid; vice-president, Carroll Coberly; secretary-treasurer, C. M. Lightburn; directors, Charles A. Davis, R. W. Lindsay, John Burgess, A. A. Mathews, Charles Leedy, E. B. Debler, and G. H. Garrett.

Change of Highway Personnel In Montana Department

Resignations of four officials of the Montana highway department have been announced by the new state highway commission. The officials resigning are D. A. McKinnon, chief engineer; E. H. Donohue, assistant chief engineer; W. O. Whipps, commission secretary; and O. J. Jawort, director of planning surveys. The board has appointed acting successors to the resigning officials: N. W. Hicks, division engineer, to be chief engineer; George Poore, reconstruction engineer, to be assistant chief engineer; O. E. Cutting, senior assistant office engineer, to be secretary to the commission; and R. H. Willcomb, assistant planning survey director, to be director.

Chief Engineer McKinnon had held his position about a year and a half. Mr. Donohue and Mr. Whipps had each served in the highway department for 16 years, and Mr. Jawort for about a year.

The new highway commission was appointed recently by Governor Holt after his removal of the previous commission. A proceeding is now before the Montana Supreme Court, brought by the State attorney-general, to determine which of the commissions is entitled to office.

Electric Plant Purchase

It was erroneously stated in the Dec. 17 issue, p. 876, that the price of an electric plant to be purchased by the city of Los Angeles from the Los Angeles Gas & Electric Corp. was $26,340,000 and that gas franchises granted to gas companies by a charter amendment were for 350 years.

The price of the electrical plant is $46,340,000, and the term for the gas franchises is 35 years.

Personals

EBEN G. HITCHINGS, associate civil engineer in the U. S. Engineer Office at San Francisco, has transferred to the National Park Service in the same city.

JOHN W. WHEELER has been appointed engineer of highway negotiations for the Burlington R. R. to handle grade crossing elimination work. Mr. Wheeler has been a member of the Indiana state highway commission since 1933 and also chairman of the Indiana state planning board.

J. B. HAYS has been appointed construction engineer and F. C. SCHLEMMER construction superintendent for the TVA on the Chickamauga Dam project. J. C. NOWELL has been appointed assistant to Barton M. Jones, acting head of the engineering design department of the TVA.

E. M. WHIPPLE, who was recently appointed superintendent of construction for the TVA on the Chickamauga Dam, has resigned that position to become superintendent in charge of construction of the Marshall Ford Dam in Texas for the contractors, Brown, Root & McKenzie.

F. T. DARROW, who has been for some years assistant chief engineer for the Chicago, Burlington & Quincy R. R. in charge of lines west of the Missouri River, has been appointed chief engineer, succeeding A. W. NEWTON, who has retired after 54 years of service but is being retained as consulting engineer for the Railroad.

W. VINCENT BARRY, for the past five months acting city engineer of New Haven, Conn., has been appointed city engineer, succeeding the late Edward S. Nettleton. Mr. Barry joined the city engineer's department in 1919 as a bridge engineer. He was formerly chief inspector of bridges for the New York, New Haven & Hartford Railroad and before that was connected with the American Bridge Company, participating in the design of the Woolworth Building and the Bankers Trust Building of New York. He is a graduate of Tufts College and the Sheffield Scientific School of Yale University.

Obituary

W. H. COLLINS, director of the geological survey of Canada from 1920 until the end of 1936, died at Ottawa in his fifty-ninth year.

JULIEN SMITH, 72, former highway commissioner of Alabama, died on Jan. 16. Mr. Smith was a graduate in civil engineering of the University of Alabama.

CLARENCE I. GLASSBROOK, 79, a retired construction engineer who formerly practiced in Salt Lake City, Utah, died in Fitchburg, Mass., on Jan. 18.

T. L. LIMMOUS, chief engineer of the board of railway commissioners of Canada, died in Ottawa on Tuesday, Jan. 19 at the age of 64.

EDWARD G. POOLE, formerly a construction engineer for the Delaware School Foundation and before that a civil engi-

neer for the Pennsylvania R. R., died on Jan. 15 in Wilmington, Del.

RAMESES A. HAMMACK, 64, a construction engineer for the Public Service Company of Colorado, died on Dec. 30.

ARMOND G. WALLACE, 52, who had been employed as a civil engineer by the Nickel Plate and the New York Central Railroads for 12 and 20 years, respectively, died recently in Cleveland Heights, Ohio.

WILLIAM H. NORCKAUER, federal aid engineer for the Louisiana highway commission, died in New Orleans on Jan. 8, aged 47. After his graduation from Louisiana State University, Mr. Norckauer joined the Louisiana state board of engineers in 1909, continuing with that body until he went to the Louisiana highway commission upon its formation in 1922. In 1930 he was appointed chief engineer of the commission and served two two-year terms, becoming federal aid engineer in 1934.

C. M. DAY, chief mechanical engineer for the U. S. Reclamation Bureau, died on Jan. 20 in Denver, Colo., at the age of 58. Mr. Day entered the reclamation service in 1936 as a mechanical draftsman at the Los Angeles Office. His special field in the service was the design of high pressure reservoir outlet valves, and he was an authority on the mechanical features of gates, valves, and other irrigation structures.

CONSTRUCTION STATISTICS FOR THE WEEK

ENGINEERING construction awards for the week total $44,800,000, compared with the average week to date for the year of $43,269,000. This week's total is made up of private, $15,107,000; public, $29,693,000; federal, $896,000; state and municipal, $28,797,000. Corresponding values a week ago are: total, $43,941,000; private, $15,317,000; public, $28,624,000; federal, $5,453,000; state and municipal, $23,171,000. A year ago the volume corresponding to this week's values was: total, $49,020,000; private, $14,008,000; public, $35,012,000; federal, $4,017,000; state and municipal, $30,995,000.

Increases for the week are registered in waterworks and unclassified. The classified subtotals are: waterworks, $7,259,000; sewerage, $2,468,000; bridges, $2,359,000; industrial buildings, $4,495,000; commercial buildings, $3,720,000; public buildings, $6,610,000; earthwork and drainage, $2,045,000; streets and roads, $4,647,000; unclassified, $11,197,000. The unclassified total is the highest this year, and is due to a new subway contract in New York City and a rail replacement program on 100 miles of Missouri-Kansas-Texas R.R.

New capital for the week is $1,829,000. The total is entirely state and municipal financing.

LARGER AWARDS FOR THE WEEK

Plant, American Can Co., Houston, Tex.	
Apartment, 158th St. and Gerard Ave., New York, N. Y.	
Hospital Buildings, Moose Lake, Minn.	
Ward Buildings, Lincoln State School, Lincoln, Ill.	
Training school buildings, Western Illinois State Teacher's College, Macomb, Ill.	
Highways, Miss.	
Bridge, east approach and first unit, West Palm Beach, Fla.	
Bridge, alter approaches and sub-structure, Simmesport, La.	
Shafts, Rondout West Branch Tunnel, Contract No. 332 and West Branch Kensico Tunnel, Contract No. 330, New York, N. Y.	
Trunk Sewer, Greece, N. Y.	
Dam, Flushing River, Flushing, N. Y.	
Dam No. 15, Mississippi River, U. S. Engineers, Ill. and Ia.	
Subway Board of Transportation, Sixth Avenue from West Eighteenth to West Twenty-seventh Streets, New York	
Re-laying 100 miles of track and other miscellaneous work during 1937, company forces, Missouri, Kansas, Texas Railroad, St. Louis, Mo.	

INDEX NUMBER

ENR Cost	1913 =100	1926 =100	ENR Volume	1913 =100	1926 =100
Jan., 1937	223.45	107.41	Dec., 1936	296	90
Dec., 1936	220.67	106.07	Nov., 1936	120	70
Jan., 1936	199.48	95.89	Dec., 1935	274	115
1936 (Av.)	206.46	99.24	1936 (Av.)	185	81
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50

CONTRACTS
(Thousands of Dollars)

	Weekly Average Jan. 1936	Prev. 4 Weeks	Week Jan. 28 1937
Fed. Government	$10,437	$3,361	$896
State and Municipal	38,655	21,128	28,797
Total public	$49,092	$24,489	$29,693
Total private	8,617	18,335	15,107
Week's total	**$57,709**	**$42,824**	**$44,800**

Cumulative to date:
1936 (5 weeks) $288,547,000
1937 (4 weeks) $173,077,000

Note: *Engineering News-Record* reports waterworks and earthwork, reclamation or waterways projects of $15,000 and over in size; other public works, $25,000, industrial buildings, $40,000; other buildings, $150,000 and over. The figures above represent the volume of contracts and large force account projects throughout the U. S. that are of these minimum sizes or over.

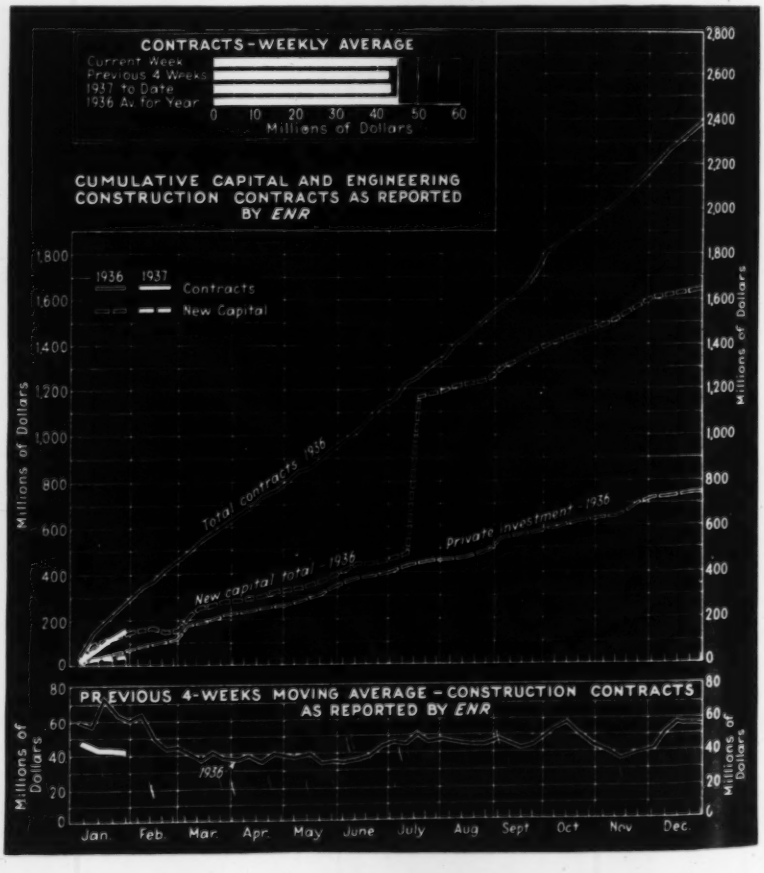
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

1937	Week Jan. 28	Cumulative
Private investment	**$16,829**	**$44,591**
State and municipal bonds	16,829	42,259†
Corporate securities	.....	2,332
Federal financing	.....	—4,061†
PWA non-federal Projects	.....	875
Total non-federal	**$16,829**	**$45,466**
Federal projects	.....	.....
Total	**$16,829**	**$45,466**

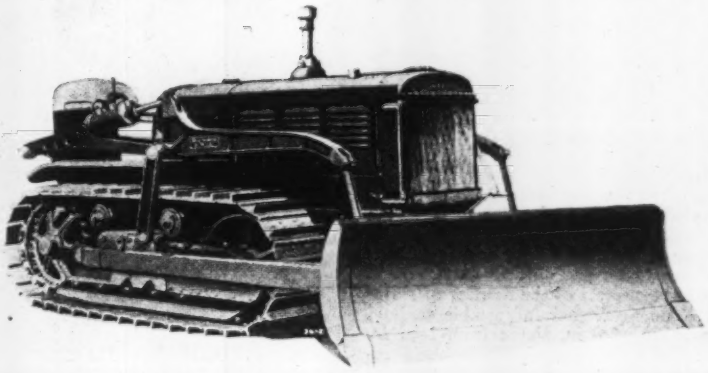
Cumulative to date:
1936 (5 weeks) $162,106,000
1937 (4 weeks) $45,466,000

Note: These figures include private bonds and stocks sold for new construction purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

† Includes transfer from federal to private investment financing through sale by RFC of PWA bonds.


CONTRACTS - WEEKLY AVERAGE
Current Week
Previous 4 Weeks
1937 to Date
1936 Av. for Year
0 10 20 30 40 50 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1936 1937
Contracts
New Capital
Total contracts 1936
Private investment 1936
New capital total 1936
Millions of Dollars
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1936
Jan. Feb. Mar. Apr. May June July Aug Sept Oct Nov Dec.

Construction Equipment and Materials



Tractor Equipment Line

A bullgrader and a bulldozer are the first units in a new line of tractor equipment announced by the Bucyrus-Erie Co., of South Milwaukee, Wis.

"Bullgrader" is a name developed by the Bucyrus-Erie Co. for their new unit, which they state can be used either for grading or for bulldozing. The blade may be set at an angle either to the right or to the left for continuous side-casting, or it may be stretched straight across for bulldozing. The blade may also be tilted for filling, or establishing a grade.

It is claimed that both these units possess a balanced design which does not materially affect the tractor's center of balance. The box-welded frame is said to eliminate the need for rubbing plates and to transmit the full load from the blade to the tractor track frame at the two points designed to take it.

The blade on these units is operated by twin hydraulic cylinders working at a maximum oil pressure of 350 lb. A single control placed near the operator enables him to raise, lower, hold, or float the blade with a blade travel speed of 32 in. in three seconds. A pressure release automatically cuts off the hydraulic power when the blade reaches its highest or lowest position.

The manufacturer states that these units may be quickly mounted on a tractor without drilling, cutting, or defacing any part of the tractor frame.

—⟡—

Four-Tine Grapple

The new four-time Type H. grapple, developed by the Owen Bucket Co., of Cleveland, Ohio, utilizes two parallel pairs of tines which function independently, gripping the object firmly on two of its sides, regardless of irregularities in shape or variations in width. This action is accomplished by incorporating a special sheave block which equalizes the gripping power and is said to eliminate any possibility of the stone or objects rolling between the tines and being dropping out.

The new Type H grapple is regularly available in three standard sizes, but it can be furnished in intermediate capacities.

—⟡—

New Hydrant Designed For Collisions

The A. P. Smith Mfg. Co., of East Orange, N. J., have faced the fact that when a hydrant is struck by a truck it will break, and have so designed their new Protectop hydrant that any impact will cause it to break at a predetermined point so that it can readily be repaired. The manufacturer states, however, that the construction is amply strong to resist any ordinary service strain.

The hydrant is made in two sections joined together a few inches above the ground line by a watertight cast iron coupling ring with an interior rubber gasket. This coupling is designed with a reduced thickness of metal at its central section which extends entirely around the hydrant. The coupling ring can be easily replaced. The hydrant main stem is made up of a lower and an upper rod joined together by a special coupling. This coupling is fastened by Duronze pins passing through the coupling and the shafts and held in place by a brass spring. The main pin coupling is assembled in line with the coupling on the hydrant case, and is so designed that any impact great enough to break the main coupling will break the stem coupling also.

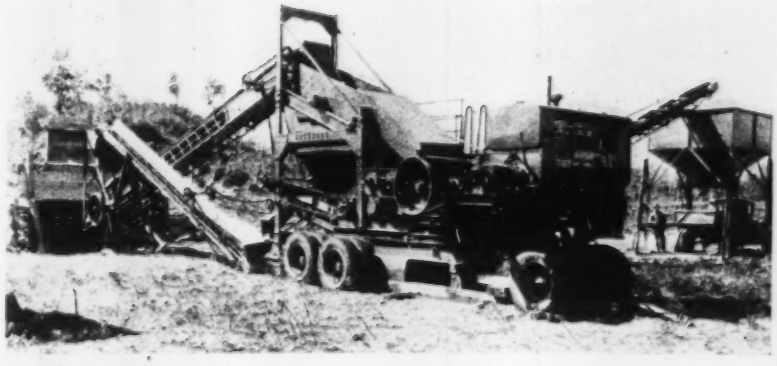
The Protectop, like all standard Smith hydrants, is of the compression type, and the hydrant valve is of such construction that if it is open at the time of the collision it will automatically close.

The manufacturer states that a broken Protectop hydrant can be repaired in 15 minutes at a parts cost of less than $5.

—⟡—

PORTABLE CRUSHING PLANT

HIGH efficiency and low cost operation are claimed for this compact gravel crushing, screening and loading plant developed by the Universal Crusher Co., of Cedar Rapids, Iowa. The assembly consists of a jaw crusher, a 30 x 16-in. roll crusher, a 4 x 8-ft. double-deck gyrating screen, and a sand rejector, mounted on a heavy-duty goose neck six-wheeled truck with 12 pneumatic tires. A 52 ft. x 24-in. feeder belt conveyor, a 52 ft. x 18-in. delivery belt conveyor, and a 21-yd. steel jackleg bin complete the assembly. Portable plants of this type are made by Universal Crusher for handling 100 to 200 tons of gravel per hour.



New Publications

✦ The T. L. SMITH Co.'s (Milwaukee, Wis.) new booklet, *Smith Tilters*, describes in 16 pages the features and the various models of the tilting mixers manufactured by that company.

✦ *Materials Handling Pumps, Pipe Line Fittings, and Rotary Dredge Cutter Heads* manufactured of manganese steel by the AMERICAN MANGANESE STEEL Co. of Chicago Heights, Ill., are described in a 19 page booklet.

✦ A good deal of information about *The Oxygen Lance* and instructions for using it for various sorts of work are condensed into seven pages by the LINDE AIR PRODUCTS Co., of New York City.

✦ Twenty-four pages in a loose-leaf format issued by the B. F. GOODRICH Co., of Akron, Ohio, describes the 1936-37 line of *Goodrich Batteries for Trucks and Buses.*

✦ Information on the use of plywood in concrete forms is contained in two pamphlets, *Facts About Douglas Fir Plywood*, and *Deflection Chart for Douglas Fir Plywood*, issued by the OREGON-WASHINGTON PLYWOOD Co., of Chicago, Ill.

✦ *Oil Testing Instruments* manufactured by C. J. TAGLIABUE MFG. Co., of Brooklyn, N. Y., are cataloged in a well printed 24 page booklet.

✦ If your copy of Fortune looks thin, look again at the cover. It is probably *Koppers*, the new booklet issued by the KOPPERS Co. of Pittsburgh, describing their nationwide activities in a style and format modeled after that magazine.

✦ A solidly bound catalog of silent chain drives is issued by the LINK-BELT Co. of Chicago, Ill., in their *Data Book 125.*

✦ A pocket-size booklet from the RANSOME CONCRETE MACHINERY Co. describes briefly the concrete machinery, ranging from 3½-S mixers and big pavers to tunnel forms and chutes, manufactured by them. The 24-page booklet is identified as *Bulletin No. 134.*

✦ An *Index of Applications* of manganese steel is issued in pocket-size by the MANGANESE STEEL FORGE Co. of Philadelphia.

Sieve Shaker

The Newark Wire Cloth Co., of Newark, N. J., has developed a testing sieve shaker for testing fine materials, the End-Shak. The shaker is provided with a simple hold-down device which permits the sieves to be put quickly in place and removed regardless of the number of sieves used. The machine is adjustable to hold any number of 8 in. sieves from 1 to 13.

The shaking motion is a combined reciprocating and turning action. Following the recommendations of the Bureau of Standards in making standard cement tests, the machine makes about 150 strokes per min., with a complete revolution of the sieve each minute. The action is designed to be gentle so that the particles roll rather than jump about on the sieve.

The operation of the End-Shak machine is said to be exceptionally quiet; the mechanism is entirely inclosed and operates submerged in oil.

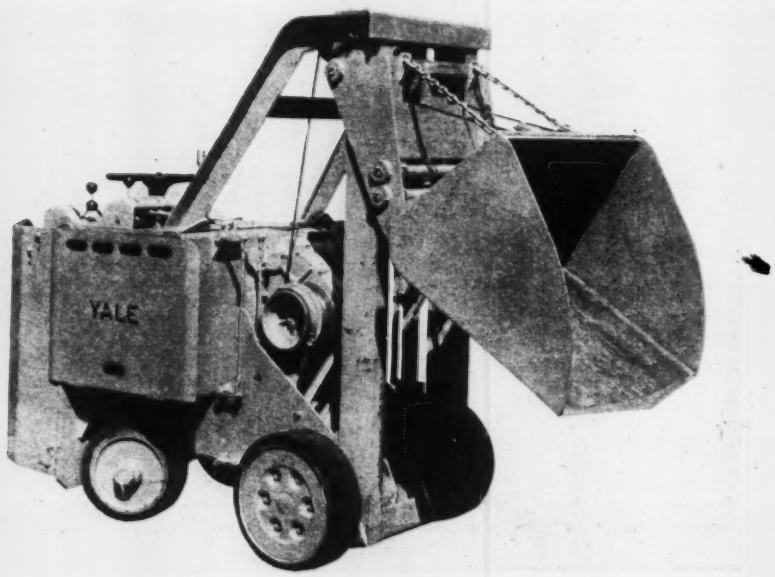
The machine, 32 in. high, and 22x18 in. in plan, weighs 145 lb., including the motor and an automatic time switch. A standard ½-hp. motor is used, operating on 110 or 220 volts, alternating current.

ROCK BREAKER

THIS pneumatic rock breaker developed by the Atlantic Steel Co. of New York City is intended to eliminate the need of explosives in breaking large boulders. The device, made of heat-treated Atsco steel, fits all standard pneumatic paving breakers. To break a boulder, the manufacturers state, it is only necessary to drill a 12-in. hole in the rock, place the rock breaker on the drilled hole and start the paving breaker. After a few strokes, it is said, the rock will split.

ELECTRIC SHOVEL ELEVATES AND DUMPS

THIS electric-driven dumping shovel scoop truck is a recent development of the Yale & Towne Mfg. Co. Philadelphia, Pa. The truck will pick up a load of 10 to 15 cu.ft., transport it to its destination, and elevate and dump the load at any height. This unit is so designed, the manufacturer states, that it is maneuverable in very congested quarters, such as the inside of a freight car.



Streamlined Dump Truck

The Easton Car & Construction Co. has developed a streamlined design in open-end, hydraulic-hoist dump bodies. This body is intended for use in quarries, coal stripping operations, and heavy excavation work. The streamlined construction is said to give unusual features in loading capacity and load distribution.

The body is built entirely of steel, using high-carbon plate steel surfaces and a structural steel frame in an arc welded and riveted assembly. A shelving of plate steel extends over and protects the cab of the truck during loading. The capacity of the truck pictured is 7 cu.yd. shaped and about 9 cu.yd. heaped. Other capacities and dimensions are available.